Industry Canada Industrie Canada

Canadian Metalcasting Technology Roadmap

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Introduction

It is sometimes difficult, when examining an industry, to retain a detached perspective. Participants in any sector are convinced that their business has special problems and issues. At some level this may be true. We have identified certain aspects which seem critical, or at least distinguish between winners and losers in the metal casting industry.

We will identify major themes here and more "micro" elements later. So what is critical?

- Access to competitive technology as required
- Access to financing and willingness to invest.
- Access to appropriately skilled workers.
- Real partnerships with key customers.
- Active and strategic marketing.
- Managerial ability.

These factors are likely valid for most sectors. This is supported by a 31 year veteran of metalcasting, who said in another context, **"Being a foundry is no excuse ..."**

These factors may be self-evident as - but why are they stressed in a *Technology* Roadmap (TRM)? Some foundries are thriving using up-to-date technology, and others are declining, not having made any technological investment for years if not decades. But one stakeholder said **"Anyone with a chequebook can get any technology they want."** So why don't they? The last five factors are supportive or enabling elements that *differentiate* between metal casters' technological performance and therefore their competitiveness.

Context

In January of 1998, the *Metalcasting Industry Technology Roadmap* was published in the United States. This was the culmination of several years of effort by the American Foundrymen's Society, the North American Die Casting Association, and the Steel Founders' Society of America, under the umbrella of the Cast Metal Coalition, and the US Department of Energy's Office of Industrial Technologies. Research projects flowing from this exercise have already borne fruit.

Industry Canada's Metals & Minerals Processing Branch (now Forest, Metal, & Building Products Branch) had been monitoring the American TRM's progress and became convinced of its value, however there were concerns about its applicability to the Canadian context, given various substantive differences between the two countries. These differences include:

- size and geographic dispersion of industry members
- strength of industry associations and level of participation
- availability of education and training relevant to the industry
- government structure and legislative differences, in particular environmental regulation and military demand for castings
- capacity for, and access to sources of financing for, research and development
- access to the US market

As well, it was recognised that recommendations in the American document dealing with *basic* research would be equally valid in Canada, but Canadian companies would have access to that technology through associations, suppliers, or American affiliates anyway.

In view of these and other differences, Industry Canada, which was already supporting TRMs in other sectors, determined the need and support for a Canadian metalcasting TRM.

With the support of the **Canadian Foundry Association**, the **Canadian Die Casters' Association**, various Canadian chapters of the **American Foundrymen's Society**, and **Natural Resources Canada** (CANMET), Industry Canada initiated a series of consultations across Canada in February and March, 1999. Additional group consultations were arranged in December 1999, and individual consultations were conducted with selected foundries and castings buyers in February, 2000 in Canada and the United States.

These consultations took two forms, facilitated meetings of industry stakeholders, including metal casters, researchers, academics, and suppliers, and individual in-depth interviews.

The *Report on Preliminary Consultations,* published in May, 1999, in many respects merely reported observations to raise awareness of the multiplicity of issues and views. The diversity of circumstances of metal casters is addressed below in **Industry Structure & Overview**. It is the intent in this report to strike a balance between analysis and reporting directly these very important comments from industry stakeholders. Solutions, where identified for further industry action, are those of the consultation participants and to some extent, of the authors.

With this current report, metal casters should be in a position to identify challenges they wish to address individually and collectively, and to assume responsibility for a course of action for dealing with them.

Technology Roadmapping - The Process

Technology Roadmapping is an increasingly popular process for industry sectors, subsectors, and even individual companies, to look forward for a specified or open-ended period, but typically 10 or 15 years, in order to identify important competitive factors over that period. The objective is to identify what capabilities, technical and otherwise, will be required to remain competitive, what barriers exist, and what must be done to overcome those barriers. In the second stage, the industry pursues whatever is necessary to implement the solutions identified.

The description "Technology Roadmap" (TRM) can be somewhat misleading. In some instances participants limit their efforts very narrowly to "hard" technology issues, while others take a much more holistic approach, dealing, for example, with infrastructural, human resources, and marketing issues in the belief that these are "enabling factors" for technology adoption. This report falls into the second group.

One of the essential principles of TRMs is that they be driven by industry members, although generally with a government agency providing support, coordination, and facilitation. An important principle is to involve a broad range of stakeholders, including equipment and materials suppliers, customers, researchers, educators, and representatives of relevant government organisations.

Industry Structure & Overview

One of the challenges of dealing with the Canadian metalcasting industry is that it is small but very diverse in a number of dimensions.

1. Customer Relationship

For the purposes of this report, three types of metal caster have been identified in respect of their relationship with their customers. These definitions, however, can be very subjective, in that we found that some facilities would characterise themselves as job shops, whereas their production runs certainly verged on production shop numbers.

> We visited one foundry explicitly divided in three by production run and casting size. The front end was largely automated and produced large volumes of castings ≤ 50 pounds, using green sand. The middle section used green sand to produce 50-500 pound castings , and the back section used nobake pepset to produce small numbers of castings over 500 pounds.

Job Shops: Tend to produce relatively short runs, as little as one-off, for a broad range of customers. This has implications for technology used, since such processes as die casting and permanent mould have high upfront tooling costs which cannot be competitively amortised over a small number of units produced, so there is a tendency towards other casting methods. As well, demand may be cyclical and more quickly reflect changes in the local economy.

Production Shops/Suppliers to Original Equipment Manufacturers: This segment of the market generally has longer term supply relationships with its customers for relatively large numbers of units. While this implies greater stability than the prior category, it also may generate greater vulnerability, since such operations may be dependent upon a small number of large customers.

These producers are often obliged to invest in high cost tooling including dies worth tens of thousands of dollars, or customers may provide and retain ownership of tooling. This group may produce a narrow range of products, or a wide range in a specific category, for example automotive manifolds. Production runs may be continuous, or intermittent, for example 200 units per week.

Captive Shops: As the name implies, these tend to be metalcasting operations embedded in larger concerns, which depend upon the internal casting shop to supply essential components or inputs for the firm's ultimate product. These firms can range from small fabrication firms, in which casting is only 10% of the business, to automotive assemblers, for whom the shop produces engine blocks. The firm may comprise one or several locations, with subsequent machining or

other operations conducted elsewhere.

Two views can be advanced of the nature of these companies. They could be viewed as metal casters with significant value added to their castings. However, in practice, most of these producers define themselves in terms of their final product and market, and castings are merely one input, for which plastics or other materials may be substituted as the market or technology evolves.

Of course, distinctions may be difficult to apply, and may be blurred, particularly between the first two groups. Traditionally, markets for job shops have tended to be relatively local, but with the advent of new technologies, this distinction is diminishing.

2. *Processes and metals*

Another aspect that makes analysis of, and generalisation concerning, this industry difficult is the broad diversity of processes used and metals poured. This diversity results in producers facing different issues, such as environmental concerns, supplier and customer relationships, Workers' Compensation rates, availability of skilled workers, access to technology, etc.

Processes used include die casting, sand casting of various sorts, centrifugal casting, permanent mould, semi-solid, lost foam, thixocasting, investment casting and so on. These in turn can be further subdivided. For example, die casting includes low pressure, gravity, cold box and hot box, and sand casting comprises green sand, no-bake, flaskless, and so on.

A broad range of alloys, from lead to cobalt, ferrous and nonferrous, are cast. The alloy used, of course, may dictate the process used as well as subsequent processing, heat treating and finishing.

One can perhaps visualise all of these variables as a matrix, with "process" along one axis and "alloy" along the other. The result is a large number of cells with each representing one material cast using a particular process. While some casters use more than one process and metal, there is generally a small number of firms in each cell, sharing metal- and process-specific interests. Added to this is the geographic dispersion of the approximately 350 metal casters across Canada, and the challenge of achieving sufficient critical mass to address issues of mutual concern.

3. *Stakeholders*

Associations: There are a number of industry associations in operation in Canada among the 350-odd metal casters. Some are casting-based and others market-based:

Canadian Foundry Association - Comprises two sections, suppliers and foundries. The CFA states that its members account for about 80% of actual production. Traditionally the CFA's orientation has been lobbying and public affairs, although this is changing as co-operation grows with the AFS. The CFA has a staff of 1½ in Ottawa.

American Foundrymen's Society - Is headquartered in Chicago, but boasts chapters in British Columbia, Ontario, and Eastern Canada. Alberta is inactive, although B.C. tries to support producers there. There has been talk of starting a chapter in Manitoba. The Eastern Canada chapter tends to be restricted to Quebec. AFS tends to be more technically- and training-related, but is recently actively co-operating with the CFA.

Canadian Die Casters Association - Comprises about 24 die casters and 40 suppliers. It shares premises with the CFA and also has 1½ employees, and is similarly government issue oriented.

North American Die Casters Association - Purports to represent die casters throughout North America. It has members, but no office in Canada. There is an active chapter in Ontario.

Steel Founders' Society of America - Several Canadian foundries are direct members, and the American affiliates of others are as well.

Foundry Educational Foundation - A Chicago-based foundation that provides scholarships and support to casting-based education. Has a strong relationship with University of Windsor.

As well, as one would expect, various metal casters are members of US and Canadian product-based associations whether the Automobile Parts Manufacturers' Association, the Prairie Implement Manufacturers' Association, or the Aquaculture Association of Canada.

Suppliers: There have traditionally been two groups, those who supply equipment, and those who supply consumable materials, whether scrap, sand, filters, or chemicals, and these two groups were consistently identified as the principal source of new technologies. Arguably, there is a new third class, providers of computer hardware and software, especially in the design area, however generally the software is distributed by traditional full-line distributors. As mentioned above, more than one foundryman has said the equivalent of "All you need to get technology is a chequebook."

Research & Development: An aspect that does not seem to be acknowledged is the

amount of R&D engaged in by Canadian foundries, perhaps because some of it is incremental and much of it is proprietorial rather than patented. This relates both to the development of machinery and processes and the development of new alloys and products. There is a broad range in attitudes towards the effectiveness of the Canadian patent system, most of it negative.

R&D is carried out by a broad range of stakeholders, notably CANMET and the Industrial Materials Institute in Boucherville. Research is carried out in some of the universities, however this tends to be computer-based simulation and modelling, given a lack of access to actual melting facilities. The University of Windsor is a notable exception to this. It is interesting that much of the research, whether in the universities or CANMET, is performed for the benefit of foreign firms. (See Appendix B for a listing of research facilities and researchers.)

Education: There is a broad range of educators and institutional commitment. UBC's engineering programme has one metalcasting elective in the fourth year of study. At the other end of the spectrum is the University of Windsor with a strong co-op casting programme, operated jointly with Ford, and with participation in the Foundry Education Foundation. There is said to be a strong programme in Trois-Rivières. The CFA, with Ontario Government funding, has established the Modern Foundry Technologies Institute in partnership with Mohawk College, due to start operation in September 2000. Even more encouraging are agreements to offer this programme on a "distance learning" basis to other educational institutions.

4. Industry Profile

A recurrent theme throughout the consultations was the industry profile, or lack thereof. The metalcasting subsector represents an early stage of production *across* most non-food manufacturing industries, rather than a vertical integrated industry such as automotive. As such, most of the output is in the nature of parts or components, sometimes not even machined, which are in turn used in more complex components of final consumer or industrial goods. Thus, the casting is invisible to the end user.

> This is not always the case, especially when the customer is a manufacturer of production machinery. One buyer said he wanted to see "minimal grinding." His company wants "it to look like a casting." A lot of competitors "hide the casting with safety equipment," but this company purposely uses Plexiglas™ to retain the casting's visibility. A buyer in another company said he would not be interested in backing off on finish to reduce cost. The appearance of the casting is an integral part of marketing and corporate image.

If people outside the metalcasting industry *are* aware of it, its image is not the best.

One of our consultation groups mentioned "the 3 Ds," "Dirty, Dull, and Dangerous." There is an image of the industry being old, low-tech, and polluting. On the other hand, in responding to a reference to the 3 Ds, an industry veteran who has *voluntarily* invested $3 million on pollution control worker safety and over the past two years, "because it was the right thing to do," commented "Being a foundry is no excuse..."

Direct customers tend to think well of Canadian metal casters and their products. We visited one plant that looked like a two-storey office building outside and was kitchen-clean inside. In another case, in a small town, the local foundry was the largest employer, paying the highest wages, and a real cornerstone of the local economy.

There is a broad range across the industry, from 3D to cutting-edge. The difficulty, both with lack of awareness and poor image, arises in a number of ways, whether with potential customers, government regulators, sources of financing, local communities, or prospective employees. For example, the head of one company with a captive foundry never refers to "foundry" when applying for a loan. He calls it "metal processing." A bank will likely regard an older foundry as a liability, rather than an asset against which to loan money.

Management

We appreciate the high level of co-operation of many CEOs we met. Managerial ability, managerial perspective, and constraints on management were issues that came up time and again.

A first consideration is the Chief Operating Officer's freedom of action. Is he/she an owner/operator with relative freedom of action but with limited access to financing? Or how about a manager of a foundry unit of a large and sophisticated international company, who has to justify his actions and spending? Is the company publicly traded or closely held; with hands-on shareholders or directors? Is management a second or third generation MBA constrained by a penny-pinching founder/owner patriarch? Is the facility a brownfield liability rather than an asset that can be used as collateral?

We interviewed one owner/operator who bought an abandoned foundry with seven mortgages and a leaking underground diesel tank in 1994. The foundry is now prospering, expanding, and unable to hire enough employees.

"The foundries have to work with what is available - success depends upon foundry utilisation, which depends on industrial engineering."

Again, we concluded that in this context foundries are no different than any other business, and management must be held to the same standard.

Virtually all metal casters, whether independent or freestanding units of larger corporations, would qualify as Small or Medium-sized Enterprises (SMEs). Perhaps the most telling comment in this context was "Foundries must be entrepreneurial." One had

A Model Division Manager

- The foundry does a lot of internal training, 40 hours per employee per year. He did 80 this year.
- A major goal is to take the waste out of the organisation. They work with "cross skill teams" to identify improvements.
- He has introduced a structure of measurable and meaningful results in the evaluation process. First priority is occupational health and safety and the environment.
- He said "You don't have to make an exception for a foundry." He has spent voluntarily over $3 million on environmental improvement over the past three years.
- A Model Division Manager (cont'd)
- The CO level on the Hunter line was over 100 ppm, although the standard is 33. The manager enclosed and vented the line at a cost of $1.5 million, reducing CO to 12 ppm
- This plant has run over 800 days without a lost time injury.
- He holds meetings for everyone in the plant each month to discuss the past month's results.
- This foundry has run over 800 days without a lost time injury.

the sense, visiting some job shops in particular, after being told that they had been established around the turn of the century, that they regarded themselves as institutions rather than entrepreneurs. There appear to be two mind sets, either entrepreneurial, looking for financial, technical, product, and marketing advantages, or defensive, adopting a bunker mentality.

In rare cases this can have a positive aspect. One owner/operator in an isolated community in which the foundry was the largest employer, stressed community responsibility, and the importance of spin-off jobs from the foundry. On the other hand, other foundries talked about the constraints imposed upon them by urbanisation surrounding their facilities.

Really, the benchmark of enlightened management is its relationship to the outside community, to its employees, and to its support of industry/ association initiatives.

In contrast to the Model Division Manager, one group of foundrymen greeted a reorganisation of their province's Workers' Compensation as a tax increase. The attitude seemed to be that the accident rate was a "given" to be taxed, rather than regarding the premium change as being an attempt to drive foundries to reduce accident rates.

This same group jokingly accepted the label "Dull, Dirty, and Dangerous," again in contrast to the Model Manager's comment on occupational health and safety. "You don't have to make an exception for a foundry."

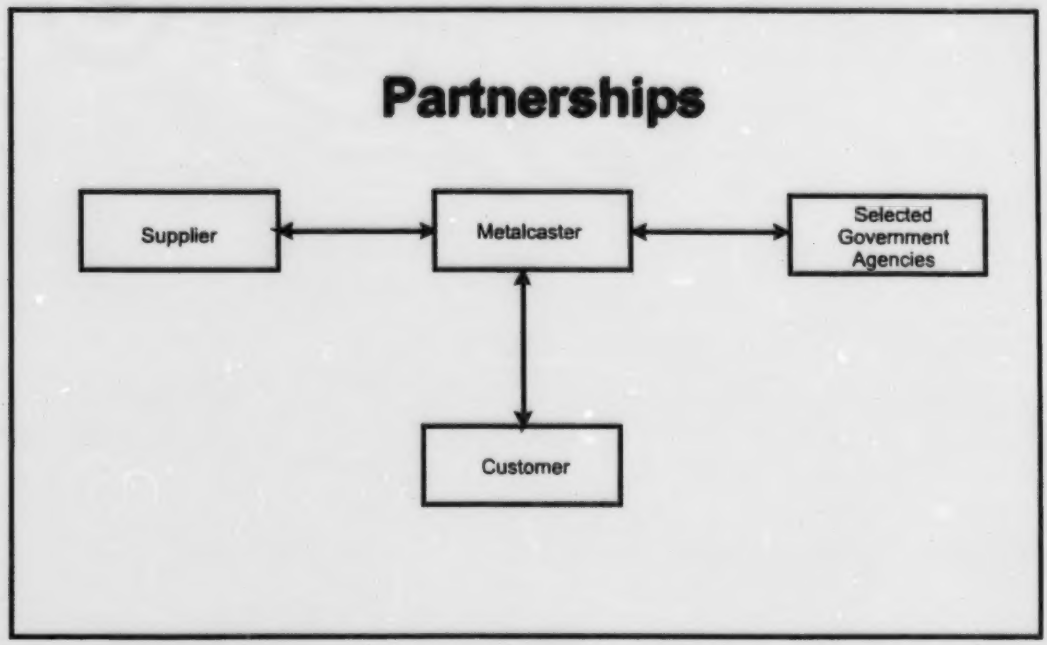
It is interesting that we encountered castings customers who wanted to see their suppliers progress, invest, do research and product development, enhance design and technical capabilities, do modelling, and so on. In many respects, they *require* these improvements as prerequisites for partnerships.

It would be a mistake to equate the theme of this section simply with good production floor housekeeping. In touring a foundry with a longstanding foundryman one senses the pride: pride in investment, in engineering, in community contribution, in creativity and ingenuity. What do they point out? The new Hunter line, the new pollution control equipment, the used agricultural conveyor incorporated into the line, the used machine bought for 6¢ on the dollar (from the US government), the new baking oven they developed, the 3 axis CNC machine converted to five axes, the computer-controlled permanent mould pouring machine developed internally, and so on.

It is excitement about this sort of thing, entrepreneurial spirit, innovativeness, and enlightened management that inspire competitiveness and pride across the whole extent of a company, regardless of what business it is in.

Partnerships

It is perhaps because of the overuse or misuse of such terms as "partnership" and "teamwork"[1] especially in a marketing context, that a responsible person is reluctant to use them. It became clear, however, as we interviewed castings *buyers* that partnerships of various kinds are very important, at least to them. These partnerships cover a broad range, from the buyer having a degree of comfort in dealing with the same supplier repeatedly, to the buyer and caster having a full-disclosure, continuing relationship that in some cases approaches full integration of the two firms.



The relationship may cover warehousing to support Just In Time (JIT) delivery, production allocation, concurrent engineering, process and product research, and so on.

It is tempting to restrict the importance of long-term relationships to production shops and die casters, but in practice we found strong long-term relationships between job shops and their customers as well. The situations described below contrast sharply with the reluctance of one group of foundries to get involved in design for fear of incurring product liability.

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[1]We view "teamwork" as involving more than two parties, e.g. customer, caster, patternmaker, machinist, heat treater, etc.

We became convinced that having met quality and service standards, partnerships are the defining criterion for which caster gets the business. The nature and diversity of the information collected suggests an anecdotal approach for this section:

★

One foundry is increasingly operating on the basis of five-year forecasts. They are meeting the competition by forecasting the customer's needs and seeking ways to serve them better. They have experimented with forecasting five customers' needs and putting their castings on open order or consignment. The result was a doubling of sales to these customers.

★

A casting customer reported an almost integrated relationship with its foundry suppliers. In qualifying foundries as suppliers it examines their sales levels, properties of metal poured, laboratories and testing available, flow analysis and modelling capability. If results from these inquiries are satisfactory, the customer sends an information package on itself and a Request for Information. If the response to the latter is satisfactory, a personal visit is conducted and a sample run is viewed.

They deal with only 3-4 foundries at a time. Suppliers of individual projects are selected from these on the basis of suitability, workload, delivery time, and so on. Foundries are required to price out each step in their process on a dollar or per cent basis, as well as providing metal to sand ratios and scrap rates. With experience, this allows the customer to identify steps that are out of line. On the other hand, they share identified savings with the foundry.

Design is a responsibility shared by all participants. This customer specifies fillets and tapers and the foundry does the gating. The customer develops a product design and layout and then calls in the foundry, patternmaker, and machinist to consult and sign off. Because of the continuing relationship, these other stakeholders see "beyond the drawing." There must be buy-in at all stages. Both the customer and foundry must sign off when the pattern shop is finished. All stakeholders must sign off after the first part is cast and fully tested.

There is almost a paternalistic attitude in this company towards its suppliers, in that it considered Chinese castings, but lacked the time and resources necessary to qualify such a supplier. "It takes a lot of work to develop a foundry."

Ironically, one interviewee stated that this firm lacks foundry knowledge.

★

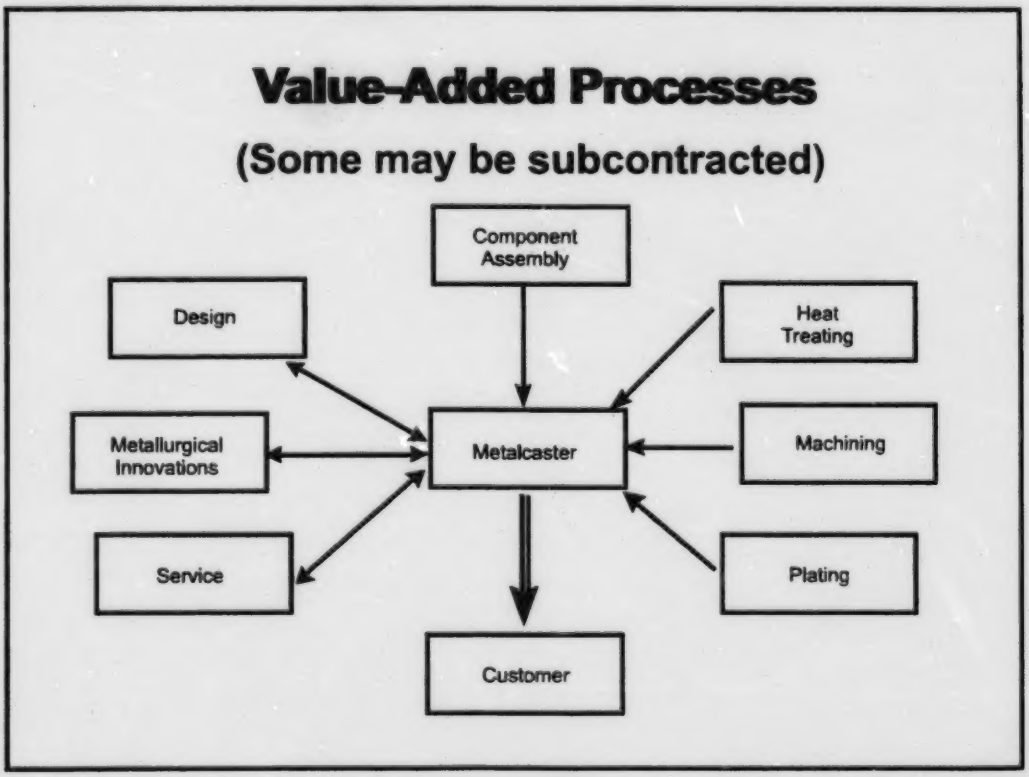
A metal caster supplying the automotive industry reports that it has an engineer resident in each of its customer's design centres, "as a key member of the design team," "as do most suppliers." It asserts that you have to be a global supplier and "follow the customer" around the world, establishing facilities to serve its plants.

The company's design engineers develop relationships with the customers' design engineers, who may be lacking in knowledge on metal casting, especially as they are bounced around from one project to another. "You need to co-design with your customer today." Those smaller suppliers unable to do this will "fall off." There is a team relationship between the die caster's engineers and marketing representatives. Production of the final design improves likelihood of getting the job.

They provide expertise and analysis, and become integral participants in the customer's design team, and frankly generate a degree of gratitude.

As well, the caster warehouses product, to provide JIT delivery.

The product offered, therefore, is a "bundle" of castings plus service.



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Another customer follows a different strategy, in that it basically buys production time on its suppliers' lines, in part to pre-empt its competitors. Criteria for foundry selection include loyalty, quality, price and delivery.

"When you find someone who knows your business, you stick with them and don't move around."

They work with one foundry which will produce "on spec," which reduces lead time. Most reliable suppliers are "malleable" and "quick on their feet." A partnership becomes a "marriage" with enough familiarity with the product that the foundry can "identify anomalies."

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We encountered one American customer said to have team relationships, consisting of confidentiality, inventory and partnership agreements, with all 432 of its suppliers. This customer was unable to find any foundry in the US capable of satisfying its particular needs. In fact, these foundries tried to rely upon the customer for the technology. They try to compete solely on price, but the operating cost is higher.

Four years ago the customer entered into a partnership with a Canadian foundry to do metallurgical development work. The foundry put together a top flight design team and invested in physical plant. (It is interesting that one of the customer's criteria for supplier selection is the latter's willingness to invest to increase market share.) The result has been improved product performance and productivity, to the extent that replacement costs, have declined 97.5% and sales growth averages 25% per annum.

The customer's strategy is to introduce new developments every year and stay two years ahead of the competition. This means that the development relationship is a close and continuing one with product performance measurement in the field, and the foundry doing failure testing of recovered product. The foundry was able to improve its tolerances so the parts can be used as-cast. It updates and verifies the dimensions of its patterns every three months,

Finally, the customer places orders on a yearly basis and adjusts flow monthly.

★

One manufacturer which contracts out all of its casting and machining, said castings from Taiwan are excellent, as is delivery, however it prefers to deal locally with long term suppliers because "you need someone who knows your product." This supplier would like to see "increased flexibility and partnerships."

★

It is notable that most interviewees, both casters and customers, who reported success and strong partnerships, valued quality, service, and delivery over price. Responses

related both to production and jobbing quantities. This appears to be an excellent strategy to meet price competition from imports.

Also E-commerce, in particular transfer of CAD files over the Internet, seemed to be a major facilitator of concurrent engineering.

E-commerce

E-commerce is generally divided into two categories, Business to Business and Business to Consumer. The former is defined as any business-related transfer of electronic data, including invoices, orders, marketing, order tracking, product design, and even distance learning.

Participants had varying degrees of experience in this area and various results. We encountered no-one who had adopted E-Commerce across the board. The most common application was the use of Email to transfer CAD designs back and forth with customers, outside pattern makers, and prototype makers, do concurrent engineering, and to translate electronic designs directly into LOM, stereolithography, CAM, and CNC programs. This obviously can decrease turnaround time and broaden the geographic scope of a foundry's business, both with suppliers and customers.

There seemed to be more interest on the side of castings *buyers* in CAD transfer, and they were often constrained by the foundries' lack of capability in this regard. Many customers commented that they were encouraging suppliers to develop E-Commerce capacity. On the other hand, some job shops reported that in 95% of cases they don't even get a paper drawing, but rather just a concept, or a worn part for replication. "You would lose 4 of 5 jobs without the ability to design from a sample." One foundry uses a portable CMM to take a pattern off a sample when quoting.

One American manufacturer relies heavily on CAD and Email to work with a Canadian foundry. The US firm is about to bring an Internet provider in-house to provide a website and order capability. Within six months all orders will be bar coded and they hope to be able to take an order and deliver next day. Clearly suppliers have to be similarly forward- thinking.

One die caster who has full-time engineers posted in OEM customers' design shops, relies heavily on E-mail for the transfer of CAD designs between the field and head office. On the other hand, some of their files are so large it is more effective to "burn a CD and courier it."

Recently the Big Three automakers announced a joint venture to develop a supply website on the Internet. This would is to be a marketplace, not only for their tens of thousands of suppliers, but also those of other automakers and manufacturing companies. If this is successful, E-commerce capabilities will clearly become a prerequisite, especially for producers of intermediate products, such as castings.

A few Canadian metal casters have excellent websites. Especially since establishing a website, but also by word of mouth, one company has sold into Japan, east and west Canada, Washington, Oregon, California, Chile, Argentina, Ireland, and from New

England to South Carolina. Another B.C. company cited receipt of an order from the southeast US because of its website.

Other companies reported lack of response to their sites, with the resultant disappointment. Websites can be an excellent marketing tool, but their existence must be publicised in other company publications, on business cards, in Canadian Company Capabilities (Industry Canada's website), etc.

Recently, a Yahoo search for the name of a prominent Canadian foundry known to have a website yielded no result. It is necessary to make sure these systems continue to function. Moreover metal casters should actively seek out hot links from other websites and make sure that appropriate key words appear in their own sites

Marketing

It is difficult to generalise across the industry because of its diversity. In the *Preliminary Report* dealing with the industry by region was considered and set aside. We were advised by interviewees more recently, however, to address the geographic issue. It may be more meaningful to address the underlying markets served, i.e. the OEM-oriented production and job shops and die casters of Southern Ontario and Quebec versus the more locally- and job shop- oriented casters in the North, on both Coasts, and in the Prairies.

Successful companies in the latter areas have transcended their locations to serve niche or OEM markets across the continent and beyond. They have achieved this through intelligent and creative management, active and strategic marketing, product development and developing partnerships.[2]

In retrospect, we have concern that the first round of interviews skewed our understanding of the range of marketing strategies pursued.

1. Marketing

> A rather isolated job shop, once largely reliant upon the mining market, now finds mining comprising only 40% of its market. This reflects recognition of its unique skills and almost missionary direct sales in Canada and the US. This was coupled with establishing close partnerships, extensive investment, and product development.

Some metalcasters have their own outside salespeople or agents outside the region, the country and even the continent. Others appear to rely upon trade shows and membership in customers' industry associations for contacts. Still others conduct sales from head office, sometimes by a "sales manager" but effectively an order clerk, or other member of the management team. In contrast, as mentioned, one in particular had no marketing people in its office, but maintained permanent sales engineers in those of its principal customers.

Whether job shop or production facility, all have had to deal with some form of globalization. Cheap imports may be bought and distributed by Canadian casters themselves, or Canadians may establish their own foundries in the Third World to internalize the profits from cheap imports. Strategic suppliers to international manufacturers, in particular automotive (due to the sharing of platforms and design), recognize the need to "follow" their customers around the world, whether by forming strategic alliances with existing casters in those other countries, or by establishing new plants there.

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[2]The reader should refer to the separate chapter called "Partnerships."

Of particular interest were those casters outside Southern Ontario and Quebec who were traditionally reliant upon local markets, whether OEM or replacement markets. These casters have faced a decline in their traditional local markets: marine, forestry, mining, and agriculture in B.C., mining, buses, and agricuiture in the Prairies, mining in Northern Ontario, and marine and forestry in the Maritimes. The important lesson to be gained is that those who had an active, strategic, geographically-diverse, and intelligent marketing plan have not suffered as badly or have even prospered, despite the disappearance of local markets.

> One foundry in the Prairies recognised that lower wage rates, lower energy costs, less strict environmental standards, and most important lower backhaul shipping rates gave it a competitive advantage in the Ontario market. In addition, this firm actively marketed in the American Midwest, to diversify its market geographically, thus reducing market fluctuation and risk.

We noted a broad range of "product bundles" ranging from a bare as-cast part, to one clustered within a full range of ancillary services. To some extent this mirrored the customer relationship, ranging from an arms-length "cash and carry" attitude to a full and deep partnership. The bundle varies, from caster to caster and of course a caster may have different relationships with different customers. The bundle may be defined by customer or caster, and may have a marketing motive or reflect product performance requirements such as heat treating.

Possible Product Bundle Components:
- design support/modelling/prototyping
- metallurgical development
- pattern making
- heat treating
- machining
- coating
- nondestructive testing
- further assembly
- warehousing to support JIT

We gained an impression that marketing was rather passive in many job shops, especially with regard to local markets, which might reflect the inability of short runs to support a major marketing effort. Competition for OEMs' business was high-powered and sometimes involved a formal bidding process, as well as considerable customer oversight of quality and other standards. One foundry sells continent-wide to OEMs on a bid basis and only 10% of business is local.

Not surprisingly, there tends to be a belief in the need for size as a necessary condition for becoming a supplier to high volume, JIT-obsessed customers such as the automobile industry. We have discussed the need to follow the customer and to have codesign capabilities but there are other critical issues. Can the supplier survive the $250,000 penalty for shutting down an auto plant for four hours? How about, as a Tier 1 supplier, access to funding - especially to front the money for a new project? Can the caster absorb the cost of warehousing to provide JIT delivery?

There appears to be a widely-held understanding across the country within the industry that the industry has a poor or nonexistent public image, and that the existing profile is of a dirty, low-tech, boring, dangerous industry populated by "people who go there because they can't do anything else." It was encouraging to hear the comments of customers in both the US and Canada as to the abilities, whether technical or in service, of various Canadian casters. Repeatedly we spoke to customers who said they couldn't find foundries in the US who could meet their needs. Some manufacturers of industrial machinery wanted the castings to be visible and "look like castings" to impart an impression of quality to the whole machine.

> "There is an historic lack of concern about the industry in Canada. The Americans understand its strategic importance." The US government monitors the availability of strategic products and makes sure the foundries stay in business. What is to stop one of the top aerospace foundries from relocating to the US?"

As noted above, captive metal casting shops may be distinguished from others in that they tend to define their core business by the end product, generally an assembly. The result is that the casting is regarded simply as an input, and there is no marketing of it *per se*, except insofar as it enhances the final product. For example, one plant manager explained that his market was his parent company's four machining plants. One aspect to note is that excess casting capacity available in captive shops does not seem to be marketed for other applications.

Solutions

The theme that ran across all types of metal casting is that successful casters have active, aggressive and service-oriented marketing programmes.

In each consultation and individual interview, participants were asked, explicitly or implicitly, to identify solutions or courses of action. These solutions vary according to the existing marketing experience of participating companies. As well, some are collective solutions, for the industry or region, and others are company-specific.

Goal: *Raise the profile of the industry to improve understanding of its importance, attract new people to it as a career and increase sales.*

1. Exhibit at customer industry trade shows and environmental shows.
2. AFS Chapter could put up a booth, staff it with volunteers, hang enlarged photos, distribute brochures, show videos
3. Approach equipment manufacturers to make them aware of casting so that they will favour casting over fabrication - put up booth at their trade shows.
4. Send promotional information to engineers.
5. Get Canadian AFS Chapters to develop a marketing plan to raise the profile of the industry
   1.select activities, e.g. industry profile in business magazines
   2.include talking to first year students at universities and to schools
   3.invite students to Chapter meetings
   4.develop booklet with list of companies
6. Companies should send their researchers to universities to inform students about the industry and their work.
7. Do company open houses and plant tours for families of employees, suppliers, politicians (every four years) - do photo opportunities.
8. Embrace and promote the foundry industry - put ads on TV.
9. Distribute the Industry Canada brochure on careers in metal casting
   - send copies to all people on the distribution list for the consultation
   - send to all universities and colleges and give to students
   - send to high schools, e.g. guidance counsellors
10. Promote the industry as the one which does the most recycling - put a small tax on the sale of a car to pay for recycling or give refund.
11. Spread the image of a good industry - show examples of foundries with low emissions - put articles in "green" publications and give examples to government decision makers of clean industries/good news stories.
12. Encourage and publicize the presence and achievements of women in the industry.
13. Promote the advantages of using castings: savings on labour due to production of fewer parts - industry could do this collectively.

Goal: Increase sales

1. Convince customers that our products are of high quality and can be available sooner than the off-shore products.
2. Patent and brand lines of product to differentiate from cheap generic imports.
3. Get government to sponsor participation in trade shows, e.g. booth, marketing trips, Team Canada, training for exporters.
4. Focus on selling finished product and develop one-stop shopping.
5. Use Website to advertise our products.
6. Put a tariff on all imports or make sure access between countries is balanced.
7. Be proactive and go out and chase markets, e.g. Seattle, Chile, Japan
   - think globally and find new customers where the action is
   - promote Canada's good reputation internationally
   - make yourselves known to Canadian engineering companies doing projects abroad
8. Work with the customer to get clarification of tolerances. Show you can reduce cost by optimising castings.

2. *Markets*

There are several ways to define markets including: geographically, mass versus niche, and OEM versus replacement. As well, in the case of OEMs, there is the issue of vertical position, i.e. Tier 1, 2, 3 etc. which may be critical to marketing effectiveness. One cannot necessarily equate OEM production with long-run or mass production, in fact, outside the transportation industry, other industries using internal combustion engines, and those producing pipe, pumps and valves, this may be the exception rather than the rule.

NAFTA, freer trade and the general globalization of markets is viewed either as a threat or an opportunity depending upon the situation of the interviewee. There seemed to be nostalgia on the part of some for the past days of protectionism.

> "The US used to buy exclusively North American and now buy around the world. There is no more protection for the foundries to keep their price up. The competitive edge of the Canadian industry is the ability to produce quickly for emergencies - this means you have to be flexible and do a quick turnaround and not tool up for large production, which means a high cost of production. The industry is like a convenience store."

Others saw the new openness as an opportunity to access new markets, in particular to diversify geographically out of failing or declining Canadian markets. E-commerce, in particular, was seen as a tool in geographic diversification.

Geographic

The difference in perspective from different regions was striking. It was observed in **Québec** that the foundries that made large iron castings for railcars had suffered because of deregulation in the US, yet several foundries in other provinces are doing very well in the railcar market.

It was similarly commented that the iron casting market was stable, because it is reliant upon machinery, municipal and agricultural castings.

Yet from the **Prairie** perspective, sales to these sectors are subject to extreme cycles. What major OEMs there are, especially those dependent on agricultural markets (up to 50%), generally are faltering. One foundry has responded successfully by diversifying into other product markets and casting processes. It also has salespeople across Canada and the US and distributorships offshore. Marketing offshore emphasises high quality, and commodity castings are avoided.

Canadian suppliers of municipal castings, even as far east as Winnipeg, complain about excessive price competition from Asia. Several have gone so far as to become distributors for offshore companies.

The Prairies were said to be a "service area," with a limited manufacturing base, that, as we have seen, leaves firms vulnerable, with a 10-15% downturn foreseen in the near term. Even within the Prairies there is some diversity, for while both Alberta and Manitoba are reliant upon agriculture, railcars and mining equipment, it is said Winnipeg does better on exports to the United States, because of the foundries' proximity to the border.

In Manitoba recreation, transport, and communications are generally doing well. Other markets include military, electronics, petroleum, "ground engaging tools," construction, locomotive parts, track parts, municipal castings and winch parts.

The US border is not the only relevant one. Manitoba foundries are able to sell into the Ontario OEM market competitively because of Ontario's high electricity rates, wage rates, and sand disposal costs, and its more stringent emission controls. As well, the freight rates on the backhaul to Ontario are lower than the fronthaul. One foundry attributed its recovery from the agricultural slump to the "southern Ontario, US and *European* markets." (emphasis added)

The **British Columbia** foundries, reliant upon area mining, fishery, and forestry markets, are suffering badly. There seems to be a very local market focus in B.C. "There will always be a need for castings locally, but the question is where they will come from." It was commented that there is little potential because of the lack of local manufacturing and because customers are moving "off-shore or to Alberta." One interviewee said that 70% of jobs in B.C. are now in the service sector. B.C. was said not to be "near the action" i.e. the Ontario automotive market, and "transportation costs are a barrier."

Local markets in the **Maritimes** include boatbuilders (Marine parts manufacture is ⅓ of some businesses), aquaculture, saw mills, and the oil industry. The fishing market is "slow."

Similar contradictions were encountered here. One Nova Scotia company has carved out a strong continental position as an innovator in fishing and in particular, aquaculture equipment. Another OEM supplier dependent on the North American market is running three shifts a day. Others, however, commented that the "potential is limited since locally there is no manufacturing." One foundry does not believe it is ready for the US market since it has "orders coming out of its ears" in Atlantic Canada.

It should be kept in mind that Nova Scotia foundries have survived the fishing crisis for ten years, as well as environmental and OHS regulation. Ironically this crisis has recently had some positive effect as boats are converted or built to fish for other species. One firm fabricated marine products for 100 years, but is getting out of it due to the death of the fishery. They now are agents for a Japanese manufacturer and this change has made the foundry division "marginal."

Ontario is usually associated with the OEM market, but one foundry visited consciously restricts itself to the continental automotive aftermarket. It is indicative of the sophistication of castings customers that one is currently doing a "global assessment" of ductile iron foundries, including 485 in the US and 40 in Canada.

The major change or challenge in the market for iron OEM castings is said to be the quest for lighter weight in the transportation market. This offers a real opportunity for aluminum, and magnesium, should it become price-competitive.

Those wishing to continue supplying the automotive OEM market, especially at the Tier 1 level, believe they have to be able to supply their customers internationally, either by establishing facilities in markets abroad, or through various forms of partnerships with analogous suppliers overseas.

The **United States**, it goes without saying, is Canada's most important export market, for a number of reasons including proximity, language, market openness, size and so on. Many foundries pursue niche market strategies that would not be viable without access to the US. Others sell into the American market to diversify risk. Some are able to supply products that American companies are apparently incapable of. Anecdotes abound of sales successes in the United States.

Some firms are very conservative with regard to exports, although they have the ability. Others export up to 75% of their production, directly or indirectly (i.e. already assembled into their customer's product - these are also called "hidden exports"). This has been fortunate, since the US market has remained relatively stable during the Canadian downturn. This stability was attributed to ⅔ of the US economy being consumer based and insulated from external fluctuations.

Vertical

As OEMs try to reduce the number of Tier 1 suppliers, metal casters must offer such services such as modelling, machining, finishing, warehousing, E-commerce capability, and even assembly, to maintain their vertical position in the market. Without Tier 1 status, they would lose direct access to the OEM, and therefore lose influence on design, ability to promote the advantages of castings over fabrication or forging, ability to promote metal (their metal), over other materials, ability to offer service bundling as a marketing tool, and in summary, basically all of their marketing levers. They would in essence become suppliers of commodity castings with quality and price as the only criteria. Their machinist or component assembling customer would do the marketing, choose between fabrication, forging or casting, hold the buffer inventory to support JIT, and so on. So why wouldn't they buy from Taiwan or China on the basis of price?

We repeatedly spoke to customers who wanted suppliers to invest, both technically and to grow. One participant was of the opinion that "Few diecasters can handle the volumes required by automotive customers." Tough problem; whose fault is that?

Castings as Products

Attitudes towards castings as products were interesting. One interviewee saw "increased use of castings in automobiles because of their lower cost and because Corporate Average Fuel Economy (CAFE) forces continued improvement."

Another customer virtually custom makes machines, with the result that dimension variations are almost infinite. As a result, they view pattern costs as a constraint and can only justify a casting if they need half a dozen pieces. They do use castings for complex shapes that are hard to machine or fabricate. "The development of technology to cut and shape metal has made fabrication more competitive with castings." Several interviewees expressed concern about pattern costs as well.

Two customers buying castings for heavy wear and impact applications said no other processes or materials can compete for their application needs at this time.

A buyer of very large castings, who was a real supporter of the process, nevertheless uses independent machinists because "foundries don't have the capacity or competitve pricing for machining."

Other strategies

There seems to be value in a strategy of narrow but continental **niche market** focus. Some casters with a narrow product focus sell to a handful of OEMs in the US and face only 3-4 competitors. A couple of firms supply only the top end of their markets (quality, innovation, and strength). Another foundry relies upon its comparative advantage in wear-resistant alloy to serve very specialized but widespread markets.

Product differentiation through branding or patent protection is a complementary strategy. One firm developed and patented a proprietary line of OEM hardware, and this comprises 80% of the business. One foundry in B.C. seems to be well regarded by its competitors for branding its products and selling them worldwide.

One marine parts producer has trouble competing with offshore standard products: e.g. the customer doesn't see the difference between a $20 shackle and one costing $5. A representative of a major foundry in Ontario said that it was difficult to show its industrial customers the difference between a Chinese and domestic part. An industrial customer had the same opinion and said the product from Taiwan was just as good, but again the bundle of services attached to the casting favoured domestic supply. This problem of competing on price alone on-off-the shelf or standard products is most acute with municipal castings across Canada, since there is little potential for bundling or product differentiation.

3. *Competitiveness*

Firms' approaches to competition vary. Some make capital investments to improve productivity and quality, others try to scrimp on wages. Some run their businesses strategically looking for competitive advantages and market opportunities, and others hunker down in something of a bunker mentality and try to hold on.

> In BC, five or six foundries have closed in the last ten years. Vulnerable companies were said by local foundrymen to have been owned by larger companies, and unionized, i.e. high cost and inflexible. Survivors are small, with low debt, low overhead, often family-owned and flexible.

Comments about competition from the Third World were generally similar across the country, but interestingly the members of the industry blamed themselves, as well as government policy, for their declining competitiveness. As well, they gave credit to the increasing technical content of parts from the Third World. Most of the concern was directed towards commodity, especially municipal, castings from Asia, particularly China.

So how are foundries, and their customers responding to this price competition?

Some foundries are importing and reselling Chinese off-the-shelf castings to compete on price. They have shifted their own production to more complex, value-added castings. They give their customers a choice between local and imported castings, and use these commodity products to fill their product lines. In one meeting this brought an emotional response from a competitor: "Why are you in business?"

A castings customer said he had had to switch to Chinese castings for standard applications because his competitors had, although he preferred Canadian castings.

Another customer buys 40 containers of Chinese manganese castings per year because there are only two potential suppliers, and North American foundries "cannot compete on price."

On the other hand, many of our interviews were with customers who surprisingly de-emphasized price as a competitive factor. These were generally machinery builders for whom the performance and continued operation of their equipment were paramount, and saw the inclusion of castings in their machinery as a marketing asset. Generally, failure or downtime of the machinery they produced was the situation to be avoided, and minimized through a quality product and rapid service. Repeatedly these customers ranked "price" as a competitive factor *after* quality, service, and delivery, because it was the image of their product and company that was at stake. Of course, downtime in their own manufacturing was also to be avoided. As one would expect, customers did not expect these criteria to change over the next ten years.

Industry Comments

- Finished and machined Chinese drums and rotors can be landed anywhere in North America for the price of a rough casting.
- It is difficult to explain to customers any difference between Chinese and domestic parts.
- Workers in foundries in China wear open-toed shoes and shorts.
- They make junk castings for retailers.
- Castings sent to North America are of equal metallurgical quality because they have been exposed to more exacting inspection. There is a 30% scrap rate and only the best are sent to North America. They "inspect quality into the product."
- Workers earn $60-100 US per month. They are on a quota system and must produce a given number of castings per day, no matter how long it takes.
- There is no environmental control, instead inspectors receive "special bonuses."
- Chinese painted forklift counterweights are sold landed for US 21¢/pound.
- The Philippines' only advantage is labour cost, since power and materials are more expensive.
- Wages in Canada are $16-18/hour as compared to $6 in Alabama, $1.50 in Mexico and $1/day in China.
- Off-shore sourcing is a problem: they don't have constraints of environment, health, safety, e.g. China - bare feet in foundries.
- Canada cannot support high wage production; we can only retain the high technology design jobs, as labour-intensive low skill jobs are going offshore.
- Countries like Germany are selling products in our markets at lower prices than we can produce.
- Landed cost of supplies is highest in the Prairies
- The cost of freight is important, especially in iron castings.
- The quality of castings from China is improving and the quality of those from Japan is very high; Korea and Thailand are going up.
- China and Korea are becoming high tech very fast.
- Off-shore products often appear to be of more quality and they seem to be advancing rapidly.
- The new Mexican foundries (Ford, Nissan) seem to be the best in the world - high tech.
- Canadian companies are near the market and can provide a faster turnaround. As a result they often get emergency castings, which implies short runs, inefficiency, and lack of specialized equipment.

Solutions:

So what can we take from the foregoing? Canada is a relatively high-cost jurisdiction, with major variations across the provinces. However when one refers to cheap castings coming in from Germany, there is a problem. Canada has relied upon the low-tech nature of Third Word castings as a competitive advantage, but now the technical advantage is disappearing due to the Third World's catching up, and maybe some Canadian foundries falling behind. What may be of the most concern are the high-tech automotive foundries in Mexico, which benefit from high-tech, low wages, and little regulation.

There was a range of government-dependent solutions identified involving tariffs, subsidies, Canadian content rules and so on, which in the current political climate and WTO regime are likely not realistic.

One idea was to survey how far "gone" are existing foundries before throwing new money into them. Evaluate technology, equipment, personnel, viability. Two foundries in BC have done this in recent years. One invested heavily and aggressively marketed a new branded product line in export markets with great success. Another decided to cease production, importing standard castings from China and contracting out other casting locally. The important lesson to be

drawn is that there may be very different solutions for different companies facing similar challenges. Someone commented it might be easier to raise money for new greenfield sites as opposed to financing sites with years of waste in/on them. Certainly there have recently been greenfield investments in Manitoba and Stratford, and other major expansions amounting to new plants elsewhere in Ontario.

Metal casters, individually, or where appropriate as a group, must seek their own solutions, rather than looking for easy and quick fixes. It is encouraging that the industry is capable of major joint projects, such as the Modern Foundry Technologies Institute.

Ideas

- Move to less labour-intensive technologies/automate as much as possible - keep sand as a sideline.
- Prepare good market and business plans to get money for investment. Include a feasibility study - Teach small companies how to do this and expose them to venture funds.
- Government should insist that funding only go to projects that have expertise.
- Focus on Tier 1 suppliers involved in exports (OEMs prefer component suppliers).
- Go to magnesium suppliers and steel companies who may support casting more than aluminum does.
- Pursue flexibility in production and material, e.g. induction furnaces for ductile, steel and grey cast iron.
- Since the value/weight ratio is a limitation on viable market area, increase the value added to permit shipping further. Machining will double or treble sales. But many of the environmental problems arise from machining and there is still not much profit.

If there was one comment that summed up an overall solution to low-priced imports it was "Recognise that Canadian foundries will never be as cheap as China's - so push service, quality, faster delivery time, and technology." We have addressed elsewhere in this report the concept of bundling services with castings to provide a more highly value added product. This appears to be the area where Canadian metal casters have an advantage. We see the Third World winning on price, at least on commodity castings, for a range of reasons, and closing the gap on quality and technical ability. (A large proportion of presenters at international casting conferences now represent Third World foundries and institutions.)

What will they want ten years from now?

Customers were asked what they would want from metal casters ten years from now. They uniformly valued quality, service, and delivery over price. Otherwise:

- Faster turnaround time - no lost business
- New alloys - better wear & impact
- Service
- Pattern development - faster
- Innovation
- Partnership
- More machining
- Better design support -FEA and solid modelling
- More competition - They'll need more castings!
- More product consistency.
- More expertise on the foundry side.
- More investment.
- Better problem solving.
- Better complaint resolution.

We believe that the bundling strategy, together with development of strong and meaningful partnerships, and improvements in productivity, both also discussed elsewhere, offer the best opportunity for a sustained competitiveness, especially in the Canadian market.

4. Trade / Commercial Barriers

Comments on trade barriers are more or less self-evident and can roughly be divided into interprovincial and international barriers.

International

1. In Canada, we do not have a country of origin law (to identify maker of a product). - Anything can come into Canada without the country of origin on it. - We have to cast a "Made in Canada" stamp. - Customs lets in products from China that had "Made in Canada" on them because there is no national standard.
2. We are encountering hassles at the US border, even our salespeople carrying literature. - It is so hard to get samples across the border, one firm uses UPS instead.
3. US patriotism makes them buy "Made in USA" but Canadians do not buy Canadian.
4. One firm does bridge building however they can only compete on temporary bridges in US because of the requirement to buy American steel on federally-funded intermodal projects. They can bid on state-funded projects.
5. With NAFTA, Mexico is getting business that used to be in the US.
6. One customer feels that NAFTA puts undue restrictions on them. Seventy per cent of their sales are to the other NAFTA countries. They feel they are "held hostage to the US foundries" because their US competitors can bring in cheap castings from offshore to incorporate in their machines for sale in the US, but the Canadian manufacturer can't bring in those same castings for a machine to be sold in the US.
7. One OEM supplier says there are only four major foundries supplying its market in the US and they cross-license technology, which acts as a barrier.
8. One foundry which ships lots of 80,000 pounds has to unload half of the truck at the border, carry on to its American customer, and return to the border to reload the other half of the shipment, due to US road weight limits.

Interprovincial

1. Quebec MOT is an interprovincial barrier- couldn't get a permit to ship girders to Ontario- had to ship via Maine.
2. There are still inter-provincial barriers to tradespeople. One can't move to another province without rewriting exams.

Solutions:

1. Have a recognized educational standard for education at post-secondary levels, e.g. engineering.
2. Level the playing field with international competitors - permit equal penetration of each other's countries.
3. Business should make itself aware of import and export regulations - government could help make business aware of where to find them.
4. Pass a mandatory "Country of origin" law.
5. Government should purchase from within the NAFTA group - make it mandatory.
6. Make Canada and US more like the EC with regard to employee mobility.

Productivity

General Comments:

Recently there has been a dispute over whether Canada's productivity is rising or falling. There appears to be some concern regarding Canada's productivity as compared to the other G7 members - and particularly with the United States.

Benchmarking

We believe that productivity is a function of technology, investment, and human resources. But how does a foundry know whether its wages are competitive, whether it is investing enough, and when it is investing in enough new technology, both compared to its competition and as a combination of complementary elements? How does it forecast market trends? How do its sales and exports compare, in absolute terms and per worker?

The associations try to provide some of this data for their members. Statistics Canada provides a lot of data, but they are very dated, and nonferrous castings data are grouped with rolling and extrusions, so as to be virtually useless. As well, for 1998 for example, only 78 iron foundries responded to Statistics Canada, whereas there are approximately 130 companies pouring iron in Canada.

It was suggested as well that since casting cuts across all sectors, a foundry producing pump housings might be more interested in pump statistics than in castings figures.

While sales and profit are excellent performance indicators in such a competitive environment, quantifying, evaluating, and comparing the inputs that produce them provides more meaningful analysis as well as facilitating planning for the future.

Statistical Data Available

- Shipments
- Exports - by country
- Export intensity
- Imports - by country
- Trade balance
- Apparent domestic market
- Share of primary metals market
- Value added/production worker
- Employment (production & non-production)
- Unit labour cost
- Wages & salaries (production & non-production)
- Energy costs
- Materials cost
- Variable costs
- Capital expenditures
- Capital to labour ratios
- Prices
- R & D expenditures
- Training expenses

(These elements can be combined to yield any measure required. Adjusted data are provided from the US for the sake of comparison.)

The level and destination country of castings exports are reported which may give metal casters a feel for potential markets as well as enabling them to evaluate their own performance.

If the information identified at the right is deemed useful, a number of strategies could be pursued by the industry, with of course, the appropriate provisions for confidentiality. The associations could request more detailed information directly, and from all industry participants. Some effort could be made to get more timely and more complete information from Statistics Canada. More meaningful information could be sought by having nonferrous casting split off from rolling and extruding, especially as they become more important in the transportation industry. What, for example, does an engine block have in common with aluminum food wrap?.

Aside from planning, these data could also be used for collective political purposes. Since the source, level and per cent change in imports: number of employees, input costs, and so on are reported, these figures could be used for import issues such as dumping, energy cost lobbying, and to quantify the industry's contribution to the Canadian economy in terms of jobs and exports.

★

The discussion of productivity has been broken into three major headings: technology, human resources and education, and investment. All three topics are major components of productivity and growth. - and all three are interrelated. For example, lack of qualified staff can slow down or cripple technological growth. Each factor in its own way may be a two-edged sword. There may not be enough internally-generated funds for a small family-owned foundry to modernize, but outside investment can lead to loss of control.

1. Technology

One comment in particular summed up the issues of technology and marketing in this sector: *"The cutting edge of die casting is as cutting edge to the industry as the cutting edge of Nortel."*

Two other assertions support our intent in this report to address the *enabling* context of technology acquisition rather than technical issues themselves:

- "If you have a cheque book you can get all the technology you want."
- The necessary technology "is a phone call away."

In other words, the technology is as available to Canadian casters as it is to casters throughout the world, generally through the international equipment and consumable suppliers. It is, however, necessary to monitor and evaluate new developments through trade journals, trade shows, conferences, the Internet, and so on.

Canadians have easy access to the largest market in the world. And as we explained earlier, the technological development strategy is in the American Roadmap. There is something of an *unjustified* inferiority complex among some Canadian metal casters.

One US customer of a Canadian foundry commented that no US foundry had been able to solve its problems, and this was not an isolated case. Other customers talked about the technical superiority and service of Canadian foundries.

In many foundries we visited, the technological advances were impressive. We did not view "technology" as being limited to use of computers but any equipment, or process, or set-up that would increase productivity, quality and service. In many cases the investment in equipment decreased the labour content in an attempt to improve competitiveness with low-cost imports. We did not limit our examination to new cutting-edge technology, but rather something new to the producer, whether bought or internally generated.

> What are, or may be, required in Canada to enhance competitiveness, are the enabling circumstances and infrastructure *to encourage adoption of existing commercially-available technology* where appropriate, rather than worrying about the leading edge or future technologies envisaged in the American Roadmap. As one interviewee said, "If you want to see where North American casting will be in 15 years go to GIFA." (A major European trade show)

> We saw a number of evolutionary, rather than breakthrough developments. Some were so incremental as to be non-patentable, and one even took a process upon which the patent had expired, and modified it to make it actually commercially feasible. Objectives ranged from energy saving, to increased control of pouring rates, to labour saving, to increasing the capabilities of existing machinery. Protection of these new developments ranged from wide open pride in them, to hanging a tarpaulin around the new machine, to full patent protection.

The broad question of technology was approached at several levels depending upon which group of the metalcasting sector was giving the answers.

There was a division between almost unbridled optimism concerning the future, versus a concern for outright survival. Clearly technology as a concept has different meanings for each group, but we heard, for example, a comment that "high tech is more important in production than jobbing shops." We strongly disagree with this comment. While the meaning of "high tech" could be debated, in the same group was another job shop using a portable CMM to take patterns off sample castings!

It was pointed out during one of our sessions that nearly two-thirds of the foundries open in Ontario just a few years ago are out of business. Of the same period, it was also said, somewhat jokingly, that all of the good foundries had gone into OEM production. The harsh reality is that metal casting is like any other business. You have to stay competitive any way

> One caster who established a greenfield plant in 1998 had planned the production floor so it could easily be doubled, which is likely in the near future. Two others were planning major new plants, and in one case doubling the number of product lines. In all of these cases, the companies were committed to leading technology and to net shape casting.

you can, and staying competitive technologically is becoming increasingly important.

> Several customers spoke of having worked in partnership with their foundries to develop new and more useful alloys. Three indicated that their specific foundries were continually developing new alloy blends to obtain sounder castings and improved properties. These customers and foundries had developed a partnering approach to mutual gain.

Whereas some metal casters are performing so well as to induce takeover bids or are growing by leaps and bounds, some small family-owned foundries are neither lucrative nor management rich. Smaller organizations may be primarily interested in maintaining market share in a shrinking and highly price-competitive market. Since obtaining funding for technology is unlikely, with prospective lenders frequently considering foundries as liabilities rather than assets, these foundries logically scrimp on costs, including labour, to remain price-competitive, especially with imports. Trying to compete on wages with the Third World is a losing strategy, *and* they fall behind technically as well. For the same reasons, if equipment is purchased, it is often 20 or 30 years old, with the same outcome.

If the proactive path is taken, large capital investments and reinvestment may be required to assure growth. This generally means larger foundries, groups or partnerships or large captive contracts with customers - likely automotive, aerospace or other high-end, high-profit or high volume sectors. These contracts may be lucrative, but the lack of diversification may represent a risk. We visited one major multi-plant company that made only six different parts.

> One job shop had purchased a bankrupt foundry site with seven mortgages on it, had cleaned it up as required and had been pouring money into it for upgrades and expansion. Its next expansion will not likely come out of cash flow but rather external financing.

We have already discussed the alleged frequent lack of familiarity with the advantages and properties of castings among the customers' engineers. Again, strong support and relationships must be developed to market the firm's new technology, and therefore improved capabilities and product advantages. Some of the industrial machinery customers interviewed saw the inclusion of good, visible castings as marketing assets for their machinery.

It would not be legitimate to associate advanced foundries with the "hot" metals such as aluminum and magnesium, at the expense of iron and steel casters. We interviewed both customers and metal casters in the ferrous sector that were developing new alloys, improving melting and casting practices, and investing in CAD systems for more rapid prototyping. The ferrous/nonferrous distinction is not determinative of a foundry's profitability and forward thinking. On the other hand, there was concern on the part of some copper/bronze casters that there was not enough support and research for their subsector.

One die caster raised the concern that NADCA standards are irrelevant to the parts he makes, as are test bars, yet the customer insists on these tests rather than those which would reflect the performance of the actual part. This is a die caster who works with American and Canadian government researchers.

- "Most steel castings are 'made' in the grinding room."
- "Most employees are grinding - the rest of the process is all automated."
- "80% of injuries are in non-value-added operations, including 50% in finishing."
- "The greatest potential for cost reduction, accident reduction and improved job satisfaction in a foundry lies in changes and improvements in the cleaning room."

One of the most important developments *within* metalworking over the past few decades has been the introduction of "near-net shaping" according to which a part is cast with dimensions so close to those required on the final assembly that little or no expensive machining is required. Improvements in patterns, mould making, pouring and alloy content have made this an attractive means of improving the casting's competitiveness through the elimination of subsequent labour-intensive operations.

Another development growing in importance, both for research and product quality, is the adoption of process sensors and controls. These not only facilitate the shift from craft to automated, scientific manufacturing, but they will also enhance product consistency and quality, particularly in long production runs. Moreover they will provide real life data for modelling the casting process.

Modelling reduces turnaround time, scrap, energy use, and so on. Some major foundries produce no castings without it, and there are several commercially available packages available for PC or work station. Selected public institutions, notably the Industrial Materials Institute in Boucherville and the Industrial Technology Centre in Manitoba, have this capacity as well. It may be that an independent modelling centre/design consultancy could be encouraged for those casters lacking the resources to do it internally. Certainly outside design consultants are already used by some foundries for product development.

We spoke to both job and production shops who reported turnaround times of less than two weeks from first customer approach to supply of a cast metal part. While these circumstances were admittedly rare, the interviewees expressed both pride and conviction that this provided an excellent marketing tool.

The most important development *outside* metalworking has been the striving for reduced weight in transportation. Somehow, the OEMs are able to walk the line between government pressure and forcing the product development onto their suppliers. Aside from non-metallic competition, the result is light metal suppliers

developing new products and in particular, enabling technologies, and ferrous suppliers engaging in design and metallurgical work to counter the encroachment upon their traditional markets. Clearly this is a trend without end. Some automotive applications may be lost to ferrous suppliers forever, but the aluminum replacements will in turn face competition from magnesium, metal matrices, and other materials.

This is a real challenge for strategic management, both for individual companies and the sector. It will force the development of strategic alliances (e.g. the Thin Wall Iron Group) to support R&D in metallurgy and design, and to lobby government agencies. Perhaps more important, companies will have to choose battles they can win, and seek other markets or products to replace sales they cannot retain. This as well may require investment in technology.

Energy Cost and Air Emissions

Two continuing themes, albeit varying in importance across the country were energy cost and environmental regulation. The CFA has recognised the importance of these with its various environmental committees, and most recently its Energy Committee. Increasing deregulation of electricity rates raises the importance of this issue. The major reason the US Department of Energy initiated the *Metalcasting Technology Roadmap* was that the US metalcasting industry was among the top seven industrial energy users and polluters.

Until recently, Natural Resources Canada operated a Mobile Laboratory pilot programme. At minimal cost to the foundry, a staffed truck visited and identified opportunities for energy savings, as well as addressing sand, pouring and other practices to reduce waste. Unfortunately NRCan had to mothball the programme because it could not support the cost, despite the 45 foundries visited reporting savings of $1,000 to $240,000.

The US has a similar programme called Industrial Assessment Centres. The major difference in the US is that they operate within a given radius from a number of different universities on a continuing basis and use students, presumably at lower cost. Given that most Canadian metal casters are within a reasonable radius of six or seven academic centres, this would be feasible here.

Given the individual and societal benefits, renewal of the Mobile Lab programme, or some combination of the two models, may be something the industry should pursue, perhaps with partnerships from other environmental and research agencies. At the very least, access to the database from the 45 foundries visited would provide excellent benchmarking data for the industry.

We must recognize the restraints that some metal casters feel. Technology is available, but costs must be justified, staff hired or trained to use it properly and products developed to optimize the equipment usage.

2. *Human Resources and Education*

Once again the sector demonstrated that it was like any other manufacturing industry, in that there was a general concern across the country regarding the lack of skilled and even unskilled labour appropriate to all elements of the metalcasting sector. The shortage is being felt everywhere: in rural areas, isolated areas, and industrialised

The joint CFA/AFS (Ontario Chapter) Education Committee with industry support, has recently produced a video and information package intended to be presented by foundries to local students to improve the awareness and image of the metal casting industry.

areas. This shortage ranges from computer/electronic specialists, engineers, industrial electricians, and metallurgists to operators capable of running and repairing the new technology equipment to people with no knowledge, but a willingness to work and learn. One interviewee said "We regard someone with two weeks in a grinding room as having foundry experience." The lack of awareness of the sector, or the impression of a dirty smokestack industry with little chance for advancement was seen as an impediment in this search for new hires. One foundryman said that he walks candidates through the foundry before even bothering to have them fill in an application.

While the low unemployment rate and skills imbalance are making recruiting a serious problem, other forces were also identified. It was said that in B.C. an employee can net 30% more on Workers' Compensation than by working due to lack of deductions. In the Maritimes, Employment Insurance was said to be too generous to justify working.

Traditionally, foundries brought in their skilled labour from Europe - but this source is drying up as opportunities in Eastern Europe and the US improve. The shortfall was also attributed to changes in immigration laws. It may be that relief could be sought from this legislation by the industry. As well, the required skills have changed, with much less emphasis on craft.

Some metal casters have consciously adopted the strategy of "de-skilling," i.e. automating the production process to the extent that "button pushers" rather than skilled tradesmen are required. To the extent that process modelling and CAD permit such tasks as gating design to be moved off the floor and into engineering, this can be a successful strategy, both in terms of HR and in reducing labour cost. Thus investment to automate or increase capacity may have the effect of "polarizing" skills requirements, and actually reducing the need for productive workers.

A second issue is upgrading the skills of existing employees. New technologies demand new skills. Workers' reluctance to deal with change is a constraint on innovation. Groups of foundries have offered Cast Metals Institute upgrading courses under the auspices of their AFS chapters (twice each year in Red Deer for about 30 attendees). Employers face a "make or buy" decision: retrain the experienced employees in the new technologies or hire someone with the computer or other skills and then train them on the intricacies of metalcasting.

Clearly there are two sources for education/training: formal, and "on the job."

Formal education starts with the universities and colleges. With the exception of the Modern Foundry Technologies Institute at Mohawk College and the programme at the Cégep de Trois Rivières, most post-secondary opportunities in metallurgy (and even less in metal casting) are being reduced and amalgamated. Examples of metallurgy programs being merged into other engineering programmes are such institutions as École Polytechnique de Montréal and Niagara College. It is said that in the three year materials programme at the Alberta Institutes of Technology, only five hours are devoted to foundry technology.

The **Modern Foundry Technologies Institute** in Hamilton is a tribute to what the Canadian casting industry is capable of, and should be a source of pride to all. Located at Mohawk College in Hamilton, the project was driven by the joint CFA/AFS (Ontario Chapter) Education Committee. With major contributions from the Ontario Government and industry members and suppliers, classes are to start in September, 2000. Agreements have been reached to offer distance education through other institutions, and more are sought.

More information is available at the CFA website: http://www.home.istar.ca/~metassn/

Comments from British Columbia

- The industry is not perceived as important, does not attract research dollars or students.
- There is no school in Western Canada.
- We are not promoting the industry and attracting high tech graduates.
- Universities are not working closely with the industry.
- The industry has to hire the UBC graduates. The graduates are leaving the province for better opportunities elsewhere.
- There is no (metalcasting) apprenticeship in BC - only one week in high school.
- University graduates (metallurgy) get only one lecture because their money comes from Alcan, Stelco and they have no professionals who can teach casting and are interested in practical metallurgy.
- Foundries don't sell themselves well - don't hire students for work terms.
- Foundries don't have the resources - financial or human - to research their problems or to pursue new technologies.
- Work in foundries is not always done by qualified personnel. It is done by "others". The work is hard, physically challenging and not motivating because the final product is not clean and shiny.

"University and college training is limited to skeletal information, lacking experienced and knowledgeable professors, offers old, inadequate or no labs, and little support for students (scholarships)."

And yet, as a counterpoint, there is the University of Windsor, with a successful co-op program at several Ford plants and with support from the American Foundry Education Foundation. Under the Ford Industrial Research Chair cutting edge casting research and skilled casting professionals are produced.

As well, one Prairie foundry reported excellent results participating in engineering co-op programmes in Manitoba and Nova Scotia, and has now hired these students on a permanent basis.

One cannot help but think that there is a major disconnect between educators and industry. In BC there were complaints that there was an inadequate programme at University of British Columbia and the graduates either left BC or went to other more attractive ("jobs in offices where they do computer simulation or consulting") and lucrative opportunities. Yet participants in the meeting could only identify 12 engineers, including management, working in the 24 BC foundries. Which came first, the lack of engineers, or the lack of market for them? There appears to be a need for mutual support. It was suggested as well that industry and educators should develop co-op programmes. Interestingly, at a subsequent meeting, a representative of the British Columbia Institute of Technology expressed a willingness to form a partnership with the industry.

This raises a point, in that there appears to be a duality in the market: university graduates such as engineers, and college-trained technicians.

Other Comments

- Red River Community College, is trying to set up a program to produce high-end production and supervisory personnel.
- There should be night school for the trades so they can earn while learning.
- One company has developed, with HRDC and union support, modularized training programs, including videos. Under HRDC's Labour Management Partnership Programme, these are designed for upgrading and promotion of existing staff and also to "rehabilitate" employees who have made mistakes.

Another complaint related to the lack of casting-specific metal casting apprenticeship programmes. We have seen figures that indicate that to have value these need to last four years or more. With the cyclical nature of the industry, and union agreements, this can be very difficult.

Most metal casters have made their own arrangements for training. One company, which has a corporate policy against importing skilled trades, has its own apprenticeship programme arrangement with a local community college. As well, it has its own onsite training facility, complete with robot.

Most companies, however, use on the job training, which has its limitations. The trainee at best learns what the trainer knows. As a way of developing employees with modern skills, this has its limitations. As well, there is concern that the trainee has no depth of knowledge of how the equipment operates, that would provide the skill to make improvements. This may be mitigated to the extent that equipment and consumable suppliers offer training.

One issue that has not been dealt with explicitly is compensation. Interviewees asserted that they offered well-paid jobs, indeed one said he paid the highest wages in town. Earnings possibilities were described in the video produced for students. Yet on

the other side we had foundrymen complaining that workers would "cross the street for 50¢ per hour." It may be that with unemployment low, foundries may underestimate the degree of competition for skilled industrial workers. Working conditions and opportunity for advancement may also be factors. This may be the most important reason for the benchmarking proposed earlier.

As noted, human resource concerns relate to all levels, from engineering graduates to the shop floor worker. It would be a simplification to say there is a general shortage of all skill levels required for foundry work. However, in every meeting and geographical area, there was a consistent theme regarding employee requirements. There are not enough skilled people to go around. Some progressive metalcasters have realized that their future lies with skilled employees and have taken the initiative and introduced the required wage packages to secure this future.

It was also clear that in general, the universities, colleges and institutes of technology do not serve the metalworking sector very well. It is clear however, that the initiative must be with the metal casting industry to raise its profile with these institutions, and to provide them with support, and a demand for their graduates.

3. Investment

We have touched upon investment in various parts of this report, in the context of technology introduction, competitiveness, and human resource issues. It should be clear that not all investments are created the same. For instance, purchase of a twenty year old machine might increase capacity, but does not inject new technology, unless updated in terms of process control, rapid tooling, etc. Environmental control equipment may not impact directly, or obviously, on the bottom line, but it has other beneficial effects.

In one round table discussion with 16 companies, the most recent major acquisition identified was a sand mixer purchased two years before. In other instances we saw modern furnaces being installed, heard of new plants and plant expansions, saw the results of $10 million in investment over the past five years in one plant, and saw $3 million in pollution equipment, voluntarily installed in another, and even a major investment in lunchroom and locker room facilities for male and female production workers.

"Energy and Environment are very topical subjects. We all know they are important and are the subject of increasing regulatory and public attention. They are also serious competitors for a foundry's scarce capital resources. I believe that as governments are mandating the higher standards in these areas so also should they make it easier for foundries to finance them. Outright grants, accelerated write-offs, subsidized consulting, loan guarantees, revolving funds to finance these expenditures from energy cost savings, no-interest loans and any combination of these and other programmes would both allow and encourage foundries to undertake these expenditures and still preserve capital for use in productivity and capacity expansion expenditures."

Different interviewees saw investment solving human resource issues in different ways: automation de-skilling production floor jobs, investment improving working conditions, investment attracting workers with the required new manufacturing skills, etc.

It is impossible to generalize between job shops and production shops in this context, except that investment in the latter may be a bit "lumpier." While it is easy to show major investments in production shops, the $10 million investment referred to was in a family-owned firm that considers itself a job shop. A highly innovative $5 million greenfield plant may have a production run as short a six. On the other hand, the $3 million environmental investment was in one plant of a huge multi-unit international corporation.

We also saw much smaller investments - sometimes mainly in time - in the internal development of technology, that had made a major difference to productivity, quality, and/or profit. Sometimes these were more gratifying, and it showed in the pride associated with them, because they arose from the ingenuity within the company, rather than being bought "off the shelf."

Investment in production, process control, and automation equipment may improve competitiveness through improved quality, consistency, tolerances, pricing, and value added per worker. Investment in rapid prototyping, E-commerce, and CAD will improve competitiveness in terms of turnaround, cost, partnership, improved design, etc.

As mentioned previously, it was apparent that prospective lenders sometimes do not think positively about lending money to traditional foundries. The word 'foundry' may even be omitted to put a more positive spin on the loan application. This is another reason to improve the industry image, where required. Aside from profitability, environmental issues may be of concern in older foundries.

Financial aspects obviously are a major concern, and the comments to the right bear consideration.

There are many positive statements regarding investment. In these cases, specific metal casters have been able to see the return that investment in new technologies such as rapid prototyping can yield.

Comments

- The ROI on heavy capital investment industries is very low and delays introduction of new technologies.
- We lack serious, aggressive tax write-offs for the industry like in the 60's - 70's, i.e. accelerated two-year write-off on capital investment in the industry.
- It would be nice to fund environmental investment through savings, but a 2-3 year payback would be required.
- The Canadian government has not done all it

Again, metal casting is like any other business, in that if you can generate a credible business case for an investment, and can obtain the necessary funds on the basis of it, then barring unforeseen circumstances, success is likely.

One participant complained that American companies are buying out Canadian companies. This appears to be a vindication of investing in the Canadian industry, as seen through the eyes of foreign companies.

Customers want to see their metalcasting suppliers investing "to increase their market share" and improve their technical capabilities whether in E-commerce and design support, process technology, or metallurgy. In some cases this is a precondition for forming a long term partnership.

As mentioned, there are those firms that are prospering and foresee this continuing, and those that are not. Not surprisingly, the former can make a successful case for expansion and modernization, and the latter face financing difficulties which may only be overcome by loss of control of the company.

The responses from the forward looking companies are very encouraging. It is clear that they view investment in new technology, staff, and upgraded working conditions as having an attractive payback. Their embracing of electronic communication is impressive as it is clear that such technologies as rapid prototyping and CAD file transfer are making these metal casters very attractive and profitable suppliers.

Government

General Comments:

In an effort to categorize the discussion points that were raised during our cross-country meetings, we decided that government and utilities fit into a reasonably cohesive package. Governmental policies and issues ran from federal to provincial and then to shared responsibilities. In an effort to characterize them correctly, the following breakdown has been structured for ease of discussion: federal, provincial, utilities and the common or shared issues.

1. Federal Issues:

Since most of these concerns have already been discussed, we will briefly highlight the concerns expressed by participants:

- There is no government assistance (e.g. no-fault loans, tax credits, an accelerated two-year write-off on capital investment) especially for pollution control.
- We do not have a country of origin law, yet we have to cast a "Made in Canada" stamp.
- There are still inter-provincial barriers - trades can't move to another province without rewriting exams because there is no national standard.
- Personal income tax in Canada is so much higher than the US that we lose workers and competitiveness. Eastern Europe has improved to the point that workers do not want to come to Canada.
- We are encountering hassles at the US border.
- We cannot import people with practical expertise due to changes in immigration laws.
- We need government support for training.
- Reduce the time needed to get patents on new products and processes.

2. Provincial Issues:

Typical comments regarding issues with the Provincial Governments are:

- The B.C. government has "attacked industry," i.e. environmental regulations, Workers' Compensation, Ministry of Labour.
- Ontario Ministry of Environment asks for higher emission standards than the US - this affects competitiveness and is unfair.
- We need to establish OHS standards across Canada - Nova Scotia doesn't have the technical capacity, so they just adopt Ontario standards, but triple their stringency "just to be sure". The result is that you have to wear a respirator in the plant.

- How to get rid of spent sand is an issue. We have to pay a middle company in Ontario where other jurisdictions can just dump -sometimes for free.
- Waste streams to landfills are an issue. We could recycle but have to learn the regulations.
- Aluminum oxide is classified as a hazardous material which means trucking it to the US.
- BC restricts business with its Waste Management Act.
- There are rising costs of Workers' Compensation - may go up to 200% The environmental regulations are difficult to assess - too stringent.
- The education and training systems at all levels should better reflect industry's needs.
- Reduce the time needed to get approval for greenfield locations.

3. Utilities:

The comments regarding utilities were generally that electricity costs varied between provinces. They ranged from highly excessive in B.C. to quite acceptable in Manitoba.

4. Common (or Shared) Issues:

- There is an uneven playing field within NAFTA concerning:
  - environmental regulation
  - power rates
  - labour laws
  - taxes
- Government purchasers look for lowest cost and do not give preference to domestic product.
- There is a need to standardize environmental regulations across the country.
- There is a need for government clarity - hard-headed regulation rather than assistance.
- Taxes are too high - personal and corporate.
- There is too much paperwork generated for and by governments.
- Look at methods to offset training costs incurred by foundries either by tax rebates or a subsidy program.
- Although education is a provincial concern, consider either a federal standard of post-secondary education or get agreement among the provinces.
- Create shorter write-off periods for capital investments when they can be directly related to encouraging regional employment recovery and sustenance.

It is clear from our consultations that the governments do have a role to play. It is normal that most participants want less government and lower taxes as well as more government support and benefits. This may reflect a need for changed government priorities.

Conclusions & Recommendations

Major Conclusion

With the application of the appropriate strategies identified in this Metalcasting Technology Roadmap, virtually any Canadian metal caster could potentially attain World Class status and successfully compete in both the domestic and export marketplace.

Supporting Conclusions:

1. Several Canadian metal casters who were interviewed during this process currently exhibit World Class characteristics.

2. Partnerships between the metal caster and selected customers are a key element in a successful supplier-customer relationship.

3. Service, new product development, reasonable delivery and quality - in many cases - were the most important factors in determining the metal caster chosen to provide the product.

4. Many customers are requesting finished components or parts. Value-added processes that are profitable allow the metal caster to offer these products.

5. Some traditional geographic and product markets are declining and the specific metal caster must find new markets or enhance capabilities.

6. Many customers are requiring JIT product and design changes. These requirements have changed the dynamics of the metal caster's work environment.

7. Enhanced, innovative, flexible and enlightened management skills are a key requirement for success and growth as a metal caster.

8. Competitive wages, enhanced 'quality-of life' packages and human resource development are required to ensure continued and sustained growth.

9. Continual education and training of the workforce is necessary.

10. Matching of required skills to the ability of the incoming new hires should be studied.

11. Technology means more to metal casters than just upgraded computer systems. Technology, in this context, translates into any equipment, resource or process improvement that reduces costs and ensures continual growth.

12. E-commerce significantly decreases the lead-time required for transfer of information, prototypes, product and invoicing.

13. Environmental, energy usage, taxation and other government-related issues need to be addressed collectively, likely by the Canadian Foundry Association.

14. The metal caster's image and awareness of this vital sector, need to be raised in the general community and, in particular, in the education sector.

15. Educators need to realize the potential for their students in the metalcasting sector.

16. A key factor to success is a strong metallurgical component being applied to the customer's needs.

17. Metal casters and their trade associations need to recognize that the threat from the Third World extends to higher priced and quality castings.

18. Metal casters need to realize that their sector is suffering from obstacles similar to other Canadian manufacturing sectors. These include: shrinking local domestic markets, a reduced skilled labour pool, flight of professionals to the United States and taxation difficulties.

Recommendations - The Next Steps

1. Each stakeholder should thoroughly study the Metalcasting Technology Roadmap and make any comments to Industry Canada and/or the Associations.

2. Determine if this should be posted as an electronic document that will remain evergreen.

3. In order to ensure environmental stewardship, a model of sustainable growth and ecological responsibility should be developed – "manage" the issue – don't just react.

4. E-commerce capabilities should be expanded and improved.

5. Education partnerships between metalcasters, their trade associations and various educational institutions should be developed.

6. Benchmarking of "best practices" in such areas as customer-supplier partnerships, technology, etc. should be encouraged.

7. The industry should consider improved access to statistical data to permit more meaningful benchmarking and performance measurement.

8. A study of casting substitutes - such as forgings and fabrications should be made so that this trend may be reversed back to the use of castings.

9. A representation should be made to the Canadian Customs and Revenue Agency (CCRA) to discuss various taxation implications.

10. Consideration should be given to an advertising campaign that introduces and accentuates the various uses of castings, similar to the advertisements in the United States for steel but more focussed on the industrial customer.

11. Follow-up meetings should be conducted to discuss collective implementation of the ideas expressed herein.

Appendix A

Canadian Metal Casters

Company	City	Fe	S	Cu	Al	Zn	Mg	Ni
ALBERTA								
American Brass & Aluminum Foundry	Edmonton			X	X	X		
Behrends Bronze Inc.	Edmonton			X	X			
Boundary Equipment Co. Ltd.	Edmonton	X						
Canada Metal Co. Ltd.	Calgary			X				
Clow Canada	Medicine Hat	X						
Delburne Foundry Ltd.	Delburne			X	X	X		
Foothills Steel Foundry Ltd.	Calgary	X	X					
Kubota Metal Corp., Fahramet Div.	Calgary	X	X					
Lethbridge Iron Works Co. Ltd.	Lethbridge	X						
M.A. Steel Foundry Ltd.	Calgary		X					
Norwood Foundry Limited	Nisku	X	X	X	X			
P.T.L.A. Precision Foundry Ltd.	Edmonton			X	X			
Quality Steel Foundries Ltd.	Edmonton	X	X					
Sovereign Casting Ltd.	Calgary	X						
Studio West Ltd.	Cochrane			X				
Thixotech Inc.	Calgary						X	
Titan Foundry Ltd.	Edmonton	X						
Trojan Industrial Distributors Ltd.	Calgary	X						
Wilderness Castings Ltd.	Athabasca			X	X			
BRITISH COLUMBIA								
Advanced Foundry Ltd.	Vancouver							
Alcast Foundry	Penticton			X	X			
Associated Foundry Limited	Surrey	X						
Bibby Ste. Croix div. of Canada Pipe Co.	Surrey	X	X					
Canada Metal (Pacific) Ltd.	Delta			X				
Canadian Autoparts Toyota Inc.	Delta					X		
Century Pacific Foundry Ltd.	Surrey	X	X					
Custom Bronze foundry Inc.	Vancouver			X				
ESCO Limited -Port Coquitlam Foundry	Port Coquitlam	X	X					
Fourway Foundry Ltd.	Vancouver			X	X			
Globe Foundry Limited	Burnaby			X	X			
Hastings Brass Foundry Ltd.	Vancouver			X	X	X		X
Highland Foundry Ltd. l'Anco Products Limited	Surrey	X	X					X
Jefferies & Co. Silversmiths Ltd.	Victoria			X				
Kobelt Manufacturing Company Limited	Surrey			X				
Metal Distributors Ltd.	Burnaby				X	X		
Midan Industries Ltd.	Langley	X	X					
Nanaimo Foundry & Eng'g Works Ltd.	Nanaimo	X	X	X	X			
Nye's Foundry Ltd.	Vancouver	X		X	X			
Ornamental Bronze Limited	Richmond			X				
Osborne Propellors Ltd.	North Vancouver			X	X	X		
Pacific Diecasting	Vancouver				X	X		

Company	City	Fe	S	Cu	Al	Zn	Mg	Ni
Pacific Mako	Langley			X	X			
Penticton Foundry Ltd.	Penticton	X						
Reliance Foundry Co. Limited	Surrey	X	X					
Robar Industries Limited	Surrey	X	X	X				
Simalex Manufacturing Company Ltd.	Langley				X	X		
Smith Bros. Foundry & Machine Works Limited	Victoria			X	X	X		
Terminal City Iron Works Limited	Vancouver	X						
Thompson Foundry Ltd.	Surrey	X	X					
Titan Foundry Group, Dobney Foundry Ltd.	Surrey	X						
Vancouver Island Brass Foundry Ltd.	Victoria			X	X			
Wellington Foundry Co.	Parksville			X	X			
MANITOBA								
Amsco Cast Products (Canada) Inc.	Selkirk		X					
Ancast Industries Ltd.	Winnipeg	X						
Automotive Accessory Company Ltd.	Winnipeg					X		
Bayco Industries	Winnipeg			X	X	X		
Canadian Bronze Co. Ltd.	Winnipeg			X	X			
Custom Castings Ltd.	Winnipeg				X	X		
Griffin Canada Inc.	Winnipeg		X					
Indutec Alchemist (1987) Inc.	Winnipeg				X			
Integra Castings Inc.	Winkler	X						
Monarch Industries Ltd.	Winkler	X						
Pattern Castings Ltd.	Winnipeg	X	X		X	X		
NEW BRUNSWICK								
Branscombe's Foundry Ltd.	Hampton				X			
Canada Iron Castings Ltd	Saint John	X						
Canadian Industrial Castings Limited	Saint John	X						
Clow Canada	Saint John	X						
Enterprise Fawcett Inc.	Sackville	X			X			
Fluid Technologies Inc.	Saint John				X			
Eastern Foundry Limited	Clarenville					X		
PRINCE EDWARD ISLAND								
Hall & Stavert Ltd.	Charlottetown	X		X	X			
Precision Products & Services Ltd.	Charlottetown				X	X		
NOVA SCOTIA								
Annapolis Forge and Foundry	Annapolis Royal			X	X			
Atkinson & Bower Limited	Shelburne			X	X			
Central Castings Ltd.	Amherst	X		X	X			

Company	City	Fe	S	Cu	Al	Zn	Mg	Ni
Hawboldt Industries (1989) Ltd.	Chester			X	X			
I.M.P. Group Ltd.	Amherst	X						
Industrial Marine Products Ltd.	Halifax	X						
Lunenburg Industrial Foundry & Engineering	Lunenburg	X		X	X	X		
Maritime Steel and Foundries Ltd.	Dartmouth		X					
Steel and Engine Products Limited	Liverpool	X		X	X	X		
ONTARIO								
Advantage WMQ Inc.	Mississauga	X	X		X			
Alcast Technologies Ltd.	Hamilton				X	X		
Alloy Casting Industries Limited	New Hamburg	X	X					
Alloy Foundry Co. Limited	Merrickville	X		X	X			
Alloy Wheels International (Canada) Ltd.	Barrie				X	X		
Alpha Foundry Inc.	Mississauga							
Alcan - Altek Automotive Castings	St. Catharines							
Alumalloy Castings Limited	Scarborough				X	X		
Aluminum Mold & Pattern Inc.	Weston				X			
Amber Technology Ltd.	Mississauga					X		
Anchor Lamina Inc.	Windsor		X					
Archie McCoy Hamilton Ltd.	Troy	X						
Armada Toolworks Limited	Scarborough					X		
Arnold Die Casting Co. Ltd.	Dundas					X		
Artcast Inc.	Georgetown			X	X			
Atkins & Hoyle Limited	Toronto			X				
A.G. Anderson Ltd.	London	X	X		X			
A.H. Tallman Bronze Co. Ltd.	Burlington			X				
Behrends Bronze Ltd.	Woodbridge			X	X			
Bell City Foundry (Brantford) Limited	Brantford	X						
Benn Iron Foundry Ltd.	Wallaceburg	X						
Bibby Ste Croix-Cambridge	Cambridge	X						
Black Clawson-Kennedy Ltd.	Owen Sound	X	X					
Bowmanville Foundry Co. Limited	Bowmanville	X						
Bram Castings Ltd.	Brampton				X			
Brown Foundry Ltd.	Morrisburg	X						
Burlington Technologies Inc.	Burlington				X			
Cambridge Brass - Masco Canada Ltd.	Cambridge			X				
Canada Alloy Castings Ltd.-Atchison Casting Corp.	Kitchener	X	X					
Canada Investment Castings Inc.	Elmira	X	X					X
Canada Metal co.	Toronto			X				
Canada Pipe Co. Ltd.	Hamilton		X					X
Caradon Ltd -Indalloy div	Mississauga				X			
Caradon Ltd - Brampton Foundries Ltd.	Brampton				X			
Carpenter Die Casting Co. Ltd	Stoney Creek				X	X		
Cash Mould & Casting Ltd.	London				X	X		

Company	City	Fe	S	Cu	Al	Zn	Mg	Ni
Castal Components Inc.	London					X		
Cello Products Inc.	Cambridge			X				
Cer-a-Met Manufacturing Ltd.	Wellington		X					
Cercor Inc.	Georgetown			X	X			
Chrysler Canada, Etobicoke Casting Plant	Toronto				X			
Clow Canada	Hamilton	X						
Cottam Diecasting Limited	Oldcastle				X			
Crane Canada Inc.	Brantford			X	X			
Crawford Castings Company Ltd.	Toronto			X				
Crowe Foundry Limited	Cambridge	X						
Cunningham Foundry & Machine Co. Ltd.	St. Catherines	X						
Custom Aluminum Foundry Ltd.	Cambridge				X	X		
C.S. Castings Limited	Orillia		X					
Dana Brake Parts Canada Inc.	St. Catherines	X						
Date Industries Ltd.	Ayr	X						
Daytom Walther Canada	Kitchener	X	X					
Deloro Stellite Inc.	Belleville	X	X					
Designed Precision Castings Inc.	Brampton		X	X	X			
Diversa Cast Technologies	Mississauga	X			X			
Dofasco Inc.	Hamilton		X					
Domestic Foundry Ltd.	Windsor	X						
Dominion Castings Limited	Hamilton		X					
Dunbar Aluminum Foundry	Kitchener				X			
Eagle Castings Inc.	Stevenville	X						
Electroline Mfg. Co. Ltd.	Windsor					X		
Elite Die Casting Inc.					X	X	X	
Engineering Dynamics	Carleton Place			X	X	X		
ESCO Ltd.-Port Hope	Port Hope	X	X					
Etobicoke Casting Plant, Daimler Chrysler .	Toronto							
Fantom Manufacturing Inc.	Thorold					X		
Fasco Die Cast Inc.	Mississauga					X		
Fiesta BBQ Ltd.	Brampton				X			
Fine Castings Ltd	Paris	X	X					
Fisher Gauge Limited -'Fishercast	Peterborough					X		
Fisher & Sons Limited	Stoney Creek			X	X			
Ford Motor Co.-Essex Aluminum Plant	Windsor							
Ford Motor Co.-Windsor Casting Plant	Windsor							
Framatome Connectors Inc.	Scarborough			X	X			
Fulton Aluminum Foundry Inc.	Brantford				X	X		
Galtaco Inc.	Brantford	X						
Gamma Foundries Limited	Richmond Hill			X	X			
General Electric (Canada) Inc.	Peterborough							
General Motors of Canada Limited	Oshawa							
GL & V Process Equipment Group Inc.	Orillia	X	X					
Grenville Castings Limited	Merrickville				X			
Grinnell Corp. of Canada Ltd.	Toronto	X						

Company	City	Fe	S	Cu	Al	Zn	Mg	Ni
Gulan Die Casting Ltd.	Mississauga				X			
Harrington Aluminum Foundry Ltd.	Woodstock				X			
Hopper Foundry (1977) Ltd.	Forest	X						
Hudson Bay Die Casting Limited	Brampton				X			
H. Imbleau & Son Ltd.	Renfrew	X						
H.E. Vannatter Limited	Wallaceburg				X			
H.J. Skelton (Canada) Ltd.	London	X						
Industrial Fine Castings	Bolton	X	X	X	X	X		
Ingot Metal Co. Ltd.	Toronto			X	X			
Iron Ikon Foundry	Windsor	X						
J & K Die Casting Limited	Scarborough					X		
JCM Non-Ferrous Foundry Ltd.	Thorold							
Johnson Matthey Limited	Brampton	X	X	X				X
Joseph Robertson Foundries Ltd.	Toronto			X	X			
Kelsey-Hayes Canada	Woodstock	X						
Kerns Metalacasting Inc.	Windsor			X	X			
KP Bronze Co. Ltd.	Aurora			X				
Kubota Metal Corp. -Fahramet	Orillia	X	X					
Lake Foundry & Machine Co.Ltd.	Grimsby	X						
Lamco International Die Cast Inc.	Thorold				X			
Leamington Ornamental Iron	Leamington	X						
Long Branch Foundry Ltd.	Miss			X	X	X		
Lucas Varity Kelsey Hayes Canada Ltd.	Woodstock	X						
L.S. Metal Foundry Inc.	Mississauga				X			
M & G Diecasting Limited	Sunderland				X			
Machine-O-Matic Limited	Newmarket				X	X		
Mars Metal (Marswell Metal Industries Ltd.)	Burlington		X					
McCoy Foundry	Troy	X						
McLean Foundry Limited	Brantford	X						
Meridian Technologies-Accurcast Division	Wallaceburg				X			
Meridian Technologies-Jutras Division	Scarborough				X			
Meridian Technologies-Magnesium Division	Strathroy						X	
Meridian Technologies-Richmond	Cornwall				X			
Meteor Foundry Co. Ltd.	Mississauga				X	X		
Microprecision Die Casting Inc.	Burlington							
Mississauga Foundry Ltd	Mississauga							
Molten Metallurgy Incorporated	Paris	X	X					
Monarch Fabricating & Die Casting Ltd.	Toronto			X	X	X		
M.M. Fabricating Ltd.	Mississauga							
Neelon Castings Ltd.	Sudbury	X						
Nelson Bronze Ltd.	New Hamburg			X	X			
Niagara Bronze Limited	Niagara Falls		X	X	X			
Non Ferrous Castings Ltd.-Rotocast	Mississauga			X	X			
Northern Ontario Castings Ltd.	Bracebridge	X						
Ontario Die Casting	Barrie					X		
Orlick Industries Limited	Hamilton				X			

Company	City	Fe	S	Cu	Al	Zn	Mg	Ni
Payne Co Inc.	Toronto				X	X		
Pattern Castings Ltd.	Toronto	X	X		X	X		
Pentacast Inc.	Strathroy							
Peninsula Alloy Inc.	Thorold	X	X					
Permacast Ltd.	St. Catharines			X	X	X		
Precise Castings Inc.	Stratford		X					X
Procast Foundries Inc.	Elmira	X						
Quint Castings Inc.	Belleville	X						
Rahnmet	North Bay			X	X	X		
Ramsden Industries Limited	London					X		
Regional Die Casting Ltd.	Stoney Creek					X		
Riverside Brass & Aluminum Foundry Ltd.	New Hamburg			X	X	X		
Shenango Industries	Carlisle	X	X	X				
Skara Metal Foundry Ltd.	Mississauga			X	X	X		
Specialty Cast Metals Limited	Niagara Falls	X	X					
Standard Induction Castings Inc.	Windsor	X						
Stittsville Foundry Limited	Stittsville	X						
Stoermer Bell & Brass Foundry	Breslau			X	X			
Summerstown Foundry Limited	Summerstown	X			X			
TC Lawrence & Son Ltd.	Cambridge			X	X			
The Hopper Foundry (1977) Liimited	Forest	X						
Thermalloy- LeMoyne Corporation	Markham		X					
Tiffany Metalcasting Ltd.	Orangeville	X						
Tesma Int'l Canada-Toral Cast	Concord				X			
Tri Cast Bronze Ltd.	Niagara Falls			X	X			
Tritech Precision Inc.-Amcan Castings Limited	Hamilton				X			
Tritech Precision Inc.-Haley Industries Limited	Haley				X		X	
Tritech Precision Inc.-Norcast					X		X	
Tritech Precision Inc.-Trimag Magnesium Die Casting							X	
Troy Custom Brass Inc.	Cambridge			X				
Trystan div Date Industries Ltd.	Ayr	X						
Varity Kelsey Hayes -Eureka Foundry	Woodstock	X						
Vernon Mfg. Corp.	Belleville				X	X		
Volkswagen Canada Inc.	Barrie							
Wabco Casting Div. Benn Iron Foundry Ltd.	Wallaceburg							
Wabi Iron & Steel Corp.	New Liskeard	X	X					
Welco Castings (1993) Inc.	Hamilton							Pb
Wells Foundry ltd.	London	X						
Wescast Industries Limited	Wingham	X	X					
Wescast Industries Limited-Brantford Div	Brantford	X	X					
Westcast Industries Limite d- Magalloy Div.	Stratford	X	X					
Western Foundry Co. Ltd.	Brantford	X						
Wotherspoon Foundry Ltd.	Oakville	X						
Wright Aluminum Ltd.	Weston		X		X	X		

Company	City	Fe	S	Cu	Al	Zn	Mg	Ni
Quebec								
Abaco Industries Inc.	Montreal				X			
Amsco Cast Products Inc.	Joliette		X					
Anchor Die Sets & Accessories	d'Anjou		X					
Alpha Casting Inc.	Ville St-Laurent		X	X	X			
Aluminum Foundry & Pattern Works Ltd.	Ville St-Laurent	X		X	X	X		
AMT Die Casting Inc.	St. Cyprien				X	X		
Belgen Inc.	Drummondville	X						
Benoit Marcoux Foundry Inc.	Laurierville							
Bibby Ste-Croix Foundries Inc.	Ste-Croix	X						
Bibby Ste-Croix -Fonderie Grand-Mere	Grand-Mere	X						
Fonderie Laperle	St-Ours	X						
Canadian Buttons Limited	La Salle					X		
Canada Metal Ltee	St-Leonard					X		
Canadian Steel Foundries Ltd.	Montreal		X					X
Caristrap International	Laval				X			
Century Products Ltd.	Ville St-Laurent					X		
Cercast (Howmet)	Montreal				X			
CIF Metal Ltee.	Robet-Sonville				X	X		
Darona Inc.	St.-Jean				X			
Dero Enterprises Inc.	Montreal North					X		
Douglas Bros. -Robert MiTchell Inc.	Ville St-Laurent				X		X	
Durus Forgings & Castings Ltd.	Pointe Claire	X	X	X	X	X		
Dynacast Canada Inc.	Pointe Claire					X	X	
Eastern Aerocast Inc.	Lachine	X			X			
Eastern Die Casting Inc. (EDC Inc.)	Ville St-Laurent				X			
Eastern Precision Casting Inc.	Lachine		X	X	X			
Entreprises Unitcast Canada Inc.	Sherbrooke		X					
Fonderie de Thetford Inc.	Thetford Mines	X	X					
Fonderie Cormier Inc.	St-Thomas-de-Joliette	X						
Fonderie Laroche Ltee	Pont Rouge	X						
Fonderie Lemoltech Inc.	Princeville				X			
Fonderie Ouellet Inc.	St-Leonard-D'Aston	X						
Fonderie Poitras Ltee	Lisletville	X						
Fonderie Rapids Enr	Chateauguay Certre							
Fonderie Saguenay Ltee	Chicoutimi	X	X					
Fonderie St Anselme Ltee	St-Anselme	X						
Fonderie St-Germain Inc.	St-Germain				X			
Fonderie St-Romuald Inc.	St-Romuald			X	X			X
Fonderie Waterloo Inc.	Waterloo	X	X					
Fonderies Mercier Ltee	Chateauguay		X	X	X			
Fondremy Inc.	Chambly			X	X	X		
Griffin Canada Inc.	St. Hyacinthe		X					

Company	City	Fe	S	Cu	Al	Zn	Mg	Ni
Highland Foundry Ltd.	Beaconsfield	X	X					
Howmet Cercast (Canada) Inc.	Montreal North			X	X			
Ilco Unican Inc.	Montreal					X		
Industries Couture Ltd.	Chicoutimi	X						
Industries Desjardins Ltd.	St.Andre de Kamouraska	X						
Industries Lyster Inc.	Lyster				X	X		
Kubota Metal Corp., Fahramet Div.	Lambert	X	X					
Laperie Foundry (1985) Inc.	St. Ours							
Les Creations le Bronzier Inc.	Cowansville			X	X			
Lyster Industries Inc.	Lyster				X			
Magotteaux Canada	Magog	X						
Mercier Foundries Ltd.	Chateauguay Centre	X		X	X	X		
Metallurgie Castech Inc.	Thetford Mines		X				X	
Metallurgie Frontenac Ltee.	Thetford Mines		X					
Montupet Ltee.	Riviere Beaudette				X			
Moulage Sous Pression A.M.T.Inc.	St. Cyprien				X	X		
Moultec Inc.	La Baie					X		
Mueller Canada Inc.	St-Jerome	X						
Noranda Metal Ind. Ltd.	Mont Joli	X	X					
Norcast Inc	McMasterville	X	X					
Paber Aluminum	Cap St. Ignace				X			
Pole-Lite Ltd. Foundry Div.	St. Philippe				X			
Powercast Manufacturing Inc.	St. Eustache				X			
Q-Zip Die Casting Inc.	St-Jean-sur-Richilieu					X		
Saint Anselme Foundry	St. Anselme	X			X			
Saint Romuald Foundry	St. Romuald			X	X			
Shellcast Foundries Inc.	Montreal				X			
Slater Steels, Sorel Forge Div.	Sorel		X					
SNOC Inc.	St-Hyacinthe				X			
Societe Manufacturiere RO-MA Inc.	Shawinigan				X			
Stone Marine Canada Ltee	Iberville				X	X		
Thetford Foundry Inc.	Thetford Mines	X	X					
Ultracast Ltee	St. leonard					X		
Vestshell Inc.	Montreal North		X					
Saskatchewan								
Blanchard Foundry Co.(Harmon Int'l Ind's Inc.)	Saskatoon	X	X					

Appendix B

Metal Casting-related Research

ACADEMIC RESEARCH CENTRES AND FACILITIES: DOMESTIC

Cégep de Trois-Rivières
3500 Rue De Courval
C.P. 97, Trois- Rivière
Quebec G9A 5E6
WWW http://cegeptr.qc.ca/

Dalhousie University
Department of Mining and Metallurgical Engineering
P.O. Box 1000
Halifax N.S. Canada B3J 2X4
Tel: (902)420-7500 Fax:420-7551
WWW http://is.dal.ca/~mmweb/

École Polytechnique de Montréal
Campus de l'Université de Montréal,
2900 Chemin Edouard-Montpetit,
Montréal, Canada
WWW http://www.polymtl.ca/index.htm

NSERC Chair on Refractory Materials
WWW http://www.polymtl.ca/udr06a.htm

Laurentian University
935 Ramsey Lake Road
SUDBURY, ON
P3E 2C6

McGill University
845 Sherbrooke St. W.,
Montréal, Québec,
Canada H3A 2T5

Metals Processing Center
WWW http://www.minmet.mcgill.ca/
Center for the Physics of Materials
http://www.physics.mcgill.ca/cmpdocs/

McMaster University
1280 Main St. W.
Hamilton, ON, L8S 4M1
Phone: (905)525-9140 ext. 24683 Fax: (905)521-2773

Faculty of Engineering Materials Science and Engineering
WWW http://mse.eng.mcmaster.ca/
Brockhouse Institute for Materials Research
WWW http://sciserv.mcmaster.ca/bimr/index.html
Walter W. Smeltzer Corrosion Laboratory
WWW http://mse.eng.mcmaster.ca/resource/corrlab.htm

Queen's University
Kingston, Ontario
Canada K7L 3N6

Materials and Metallurgical Engineering
WWW http://cheemat.chee.queensu.ca/mat/
Materials and Manufacturing Ontario
WWW http://www.queensu.ca/ocmr/

Technical University of Nova Scotia
The Minerals Engineering Centre
WWW http://www.dal.ca/~daltech/researchcentres.html

Université du Québec
Centre québécois de recherche et de développement de l'aluminium
WWW http://www.cqrda.d4m.com/
Chaire industrielle relative à la solidification et à la métallurgie de l'aluminium
WWW http://www.uqac.uquebec.ca/decsr/cirsma.html
Centre d'études sur les ressources minérales (CERM)
WWW http://www.uqac.uquebec.ca/decsr/cerm.html

Université Laval
Department of Mining and Metallurgy
Ste-Foy, Quebec
Canada, G1K 7P4
WWW http://www.gmn.ulaval.ca/

Chaire de recherche sur les technologies de transformation du magnésium
WWW http://www.ulaval.ca/vrr/rech/Regr/00067.html
Groupe de recherche appliquée sur les matériaux industriels de pointe
WWW http://www.ulaval.ca/vrr/rech/Regr/00146.html
Groupe de recherche sur les applications de l'informatique à l'industrie minérale
WWW http://www.gel.ulaval.ca/~desbiens/graiim/html/graiim_e.html

University of Alberta
536 Chemical-Mineral Engineering Building
Edmonton, Alberta T6G 2G6

Advanced Materials Processing Laboratory (AMPL)
WWW http://www.ualberta.ca/CHEMENG/henein/AMPL.HTM
Advanced Engineered Materials Centre
WWW http://www.uaem.ualberta.ca/

University of Alberta Chemical and Materials Engineering
Edmonton, Alberta
Canada T6G 2R3
1 403 492 3111
WWW http://www.ualberta.ca/dept/chemeng/

University of British Columbia
The Center for Metallurgical Process Engineering
Advanced Materials & Process Engineering Laboratory
2355 East Mall
Vancouver, B.C. V6T 1Z4
WWW http://www.science.ubc.ca/~ampel/centre.html

UBC Metals and Materials Engineering
2329 West Mall
Vancouver, BC
V6T 1Z4
WWW http://www.mmat.ubc.ca/

University of Toronto
Department of Metallurgy and Materials Science
184 College Street
Toronto, ON M5S 1A4
WWW http://www.ecf.utoronto.ca/apsc/mms/

University of Victoria
Center for Advanced Materials and Related Technology
Box 1700
Victoria, B.C. Canada
V8W 2Y2
WWW http://www.research.uvic.ca/Research@Uvic/UVic-Centres/CAMTEC.htm

University of Waterloo
200 University Ave. W.
Waterloo, Ontario, Canada N2L 3G1
Phone: (519) 885-1211 Fax: (519) 888-6197

Materials Engineering and Processing Group
WWW http://mecheng1.uwaterloo.ca/
Waterloo Centre for Materials Technology
WWW http://watmat.uwaterloo.ca/

The Canadian Industrial Innovation Center
WWW http://www.innovationcentre.ca/

University of Western Ontario
Room G1, Western Science Centre,
London, ON N6A 5B7

Surface Science Western
WWW http://www.uwo.ca/ssw/

ACADEMIC RESEARCH CENTERS & FACILITIES: INTERNATIONAL

UNITED KINGDOM

University of Bath

Department of Materials Science and Engineering
http://www.bath.ac.uk/Departments/MatSci/
School of Materials Science - Crystal Growth
MatSci/Research/Crystals/ http://www.bath.ac.uk/Departments/MatSci/Research/Crystals/
Ceramics Research Group
http://www.bath.ac.uk/Departments/MatSci/Research/Ceramics/

University of Birmingham
WWW http://www.bham.ac.uk/metallurgy/

University Of Oxford Department Of Materials
WWW http://www.materials.ox.ac.uk/

EUROPE

Katholieke Univiversity Leuven
Department of Metallurgy and Materials Engineering
WWW http://www.mtm.kuleuven.ac.be/

Fraunhofer Institute for Applied Materials Research
WWW http://www.ifam.fhg.de/fhg/ifam/e_ifam.html

Freiberg University
Institute of Physical Metallurgy
WWW http://www.ww.tu-freiberg.de/mk/ind_eng.htm

Max Planck Institute
WWW http://www.mpie-duesseldorf.mpg.de/

Department of Metallurgy
Department of Metal Working
Department of Physical Metallurgy
Department of Materials Technology

Technical University of Delft
Laboratory of Materials Science
WWW http://www.lmak.stm.tudelft.nl/index.html

Institute of Materials Research
WWW http://www.kp.dlr.de/WB-WF/Welcomee.html

Jönköpings University
Component Technology - Castings
WWW http://www.hj.se/ing/komponent/

Netherlands Institute for Metals Research (NIMR)
WWW http://www.nimr.nl/

Royal Institute of Technology (KTH), Stockholm
Material Science and Engineering
WWW http://www.met.kth.se/

Stanislaw Staszic University of Mining and Metallurgy
WWW http://www.uci.agh.edu.pl/

Université des Sciences et Technologies de Lille: Materials
WWW http://www.univ-lille1.fr/ustl.nt/recherche/axe51.htm

University of Oxford: Department of Materials
WWW http://www.materials.ox.ac.uk/

Zurich Institute of Metallurgy
WWW http://www.met.mat.ethz.ch/index.html

UNITED STATES

Cambridge University
Department of Materials Science and Metallurgy
WWW http://www.msm.cam.ac.uk/

Carnegie Mellon University
Center for Iron and Steel Research
WWW http://neon.mems.cmu.edu/cisr/cisr.html

Massachusetts Institute of Technology

Materials Processing Center
WWW http://web.mit.edu/mpc/www/

Purdue University
WWW http://MSE.www.ecn.purdue.edu/MSE/Welcome/

Penn State
Metals Science and Engineering
WWW http://www.ems.psu.edu/Metals/

University of California, Berkeley
Department of Material Science and Metallurgical Engineering
WWW http://www.mse.berkeley.edu/

University of Dayton
Metals and Ceramics Research Institute
WWW http://www.udri.udayton.edu/MET_CERA/
glasslab/default.htm

University of Mississippi
Composite Materials Research Group
WWW http://cypress.mcsr.olemiss.edu/~melackey/

University of Nevada
Department of Chemical and Metallurgical Engineering
WWW http://www.seismo.unr.edu/cmet/index.html

AUSTRALIA

CRC for Alloy and Solidification Technology
WWW http://www.minmet.uq.edu.au/~cast/

GOVERNMENT RESEARCH CENTRES AND ASSOCIATIONS: DOMESTIC

Alberta Research Council
250 Karl Clark Road
Edmonton, Alberta
Canada T6N 1E4
Tel: (403) 450-5111 Fax: (403) 450-5333
WWW http://www.arc.ab.ca/

Advanced Industrial Materials and Processing Group
Corrosion and Electrochemical Engineering Laboratory

Canadian Lightweight Materials Research Initiative (CLiMRI)
WWW http://www.nrcan.gc.ca/mms/canmet-mtb/mtl/ENG/test/climri/default_e.htm

Center de recherche industrielle du Québec (CRIQ)
8475, avenue Christophe-Colomb
Montréal (Québec), Canada H2M 2N9
Telephone :(514) 383-1550 Fax :(514) 383-3250 Toll free :1 800 667-4570
Parc technologique du Québec métropolitain
333, rue Franquet
Sainte-Foy (Québec), Canada G1P 4C7
Telephone : (418) 659-1550 Fax: (418) 652-2251 Toll free :1 800 667-2386
WWW http://www.criq.qc.ca/index.html

INova Corp Advanced Materials Engineering Center
101 Research Drive, P.O. Box 790,
Dartmouth, Nova Scotia,
Canada B2Y 3Z7.
WWW http://www.innovacorp.ns.ca/sectors/ame.htm

Materials and Manufacturing Ontario (Centre of Excellence)
The Promontory II : Sheridan Science and Technology Park
2655 North Sheridan Way, Suite 250
Mississauga, Ontario, Canada L5K 2P8
Tel: :905-823-2020 Fax: 905-823-4141
E-mail: info@mmo.on.ca
WWW http://www.mmo.on.ca

Natural Resources Canada
555 Booth Street
Ottawa, Ontario, Canada K1A 0E4
Tel (613) 947-6580
Fax: (613) 947-4198
WWW http://www.NRCan.gc.ca:80/homepage/index.htm

Mining and Mineral Sciences Laboratories
CANMET Energy Technology Centre
CANMET Minerals and Metals

National Research Council of Canada
WWW http://www.nrc.ca/

NRC Research Institute Industrial Materials Institute
Integrated Manufacturing Technologies Institute
NRC Institute for Research in Construction

Natural Sciences and Engineering Research Council
350 Albert Street
Ottawa, Ontario K1A 1H5
Tel: (613) 995-5992
Fax: (613) 992-5337
WWW http://www.nserc.ca/

Saskatchewan Research Council
15 Innovation Blvd.
Saskatoon, SK
Canada S7N 2X8
WWW http://www.src.sk.ca/

GOVERNMENT RESEARCH CENTERS: INTERNATIONAL

The International Union of Materials Research Societies
WWW http://mrcemis.ms.nwu.edu/iumrs/index.html

EUROPE

European Commission Joint Research Center
Institute for Advanced Materials
PettenWesterduinweg, 3
NL-1755 ZG PETTEN - PAYS-BAS
P.O.Box 112 /118
WWW http://www.jrc.org

European Research and Technology Information Network (EuRaTIN)
WWW http://www.euratin.net/

EUREKA
WWWhttp://www.eureka.be/

German Aerospace Research Establishment
Köln Materials Research Institute: Ceramics Department
German Aerospace Research Establishment
D - 51140 Cologne, Germany
WWW http://www.ikts.fhg.de/ikts.engl.html

Laboratoire de Minéralogie-Cristallographie Paris
WWW http://www.lmcp.jussieu.fr/index_en.html

Netherlands Institute for Metals Research (NIMR)
628 AL Delft P.O. Box 5008
2600 GA Delft The Netherlands
Telephone: - (31) - 15 - 278 25 35 Telefax: - (31) - 15 - 278 25 91
WWW http://www.nimr.nl/

Risoe National Laboratories Materials Research Department
Frederiksborgvej 399
P.O.Box 49 DK-4000 Roskilde
Denmark
phone+45 4677 5700 fax+45 4677 5758
http://www.risoe.dk/afm/index.htm

Russia Institute of Metal Physics
Ul. S. Kovalevskoi 18
RUS - 620219 Ekaterinburg
Tel: ++ 7 343 2 44 4174
Fax: ++ 7 343 2 44 5244
WWW http://www.nikhefk.nikhef.nl/~ed/docs/russia1.html/#30504

Russia Institute of Metallurgy
Amundsena 101
RUS - 620219 Ekaterinaburg
++ 7 343 2 28 5300
++ 7 343 2 28 6130
WWW http://www.nikhefk.nikhef.nl/~ed/docs/russia1.html/#30510

State Research Center Of The Russian Federation I.P.Bardin
Central Research Institute for Ferrous Metallurgy
WWWhttp://www.extech.msk.su:8082/src_eng/
catalog/34/34e-gnz.htm

ASIA

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HKPC Building, 78 Tat Chee Avenue, Yau Yat Chuen, Kowloon, Hong Kong
Tel: (852) 27885678, Fax: (852) 27885900,
WWW http://www.hkpc.org/hkpc/html/nhome.html

HKPC Services Manufacturing Technologies

Iron and Steel Institute of Japan
Keidanren Kaikan, 3rd Floor
9-4, Otemachi 1-chome
Chiyoda-ku, Tokyo, 100 Japan
WWW http://www.isij.or.jp/e_index.htm

Japan Agency of Industrial Science and Technology MITI
Japan Mechanical Engineering Laboratory
WWW http://www.mel.go.jp/e/index.html

Japan Institute of Metals
Aoba Aramaki, Aoba-ku
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Fax. +81-22(domestic 022)-223-6312
WWW http://wwwsoc.nacsis.ac.jp/jim/index-e.html

Metals Industry Research and Development Center (MIRDC),
MIRDC Compound Gen. Santos Ave. Bicutan,
Taguig, Metro Manila
Tel. No. 837-04-31 to 38 Fax No. 837-04-30
WWW http://www.dost.gov.ph/DOST/MIRDC/homepage.html

National Research Center for Metals (Japan)
WWW http://www.nrim.go.jp:8080/public/kikaku/english/index.html

National Science and Technology Development Agency: Thailand
WWW http://www.nstda.or.th/html/national_centers_
and_major_programs.html

National Metal and Materials Technology Center
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Tel: (+662) 6448150-99 Fax: (+662) 6448027-9
WWW http://www.mtec.or.th/

Agency of Industrial Science and Technology
WWW http://www.aist.go.jp/MEL/enghome.html

Taiwan: **Industrial Technology Research Institute, Materials Research Laboratories**
WWW http://www.mrl.itri.org.tw/mrl_e.htm/

Taiwan: **Metal Industries Research and Development Center**
WWW http://www.mirdc.org.tw/english/index.htm

UNITED STATES

Berkeley National Laboratory Materials Science Division
WWW http://www.lbl.gov/msd/index.html

Federal Research in Progress Database United States
WWW http://grc.ntis.gov/fedrip.htm

Naval Research Laboratory
Material Science and Components Technology Directorate
WWW http://www.nrl.navy.mil/organization/Code6000.htm

The National Center for Manufacturing Sciences
WWW http://www.ncms.org/

National Center for Excellence in Metal Working Technology
1450 Scalp Avenue
Johnstown, PA 15904
(814) 269-2731
WWW http://www.ncemt.ctc.com/

Oak Ridge Centers for Manufacturing Technology Metals & Ceramics
P.O. Box 2008, Oak Ridge, TN 37831
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WWW http://www.ms.ornl.gov/mchome.htm

US Dept of Energy: Metallurgy and Ceramics. Ames Laboratory
WWW http://www.external.ameslab.gov/
mat_ref/met.html

US Dept of Energy: Albany Research Center
1450 Queen Ave., SW
Albany, OR 97321
WWW http://www.alrc.doe.gov/index.html

United States Department of Commerce
National Institute of Standards and Technology: Ceramics Division
Phone: (301) 975-6119 • • Fax: (301) 975-5334
WWW http://www.ceramics.nist.gov/

United States Federal Laboratory Consortium
http://www.fedlabs.org/

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Integrated Manufactured Products Sector of CSIRO
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WWW http://www.csiro.au/page.asp?type=sector&id=IntegratedManufacturedProducts

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CASTING - OTHER SITES

Office of Industrial Technologies
http://www.oit.doe.gov/
These pages provide a brief summary of current metal casting research projects funded through the US Department of Energy
On trouve dans ces pages un bref résumé des projets de recherche sur la fonderie des métaux financés par l'entremise du Department of Energy des États-Unis.

Office of Industrial Technologies: Metalcasting Industries of the Future
http://www.oit.doe.gov/metalcast/
Beyond 2000: A Vision for the American Metalcasting Industry
http://www.oit.doe.gov/metalcast/mcvision.shtml

Advanced Casting Technologies in Japan and Europe - World Technology Evaluation Center Panel Report
http://itri.loyola.edu/casting/toc.htm

Casting Technology - National Center for Excellency in Metalworking Technology
http://www.ncemt.ctc.com/thrustAreas/casting/rapidCast/

Casting Source Directory - American Foundrymen's Society, Inc.
http://www.castingsource.com/

British/ European Foundry Online
http://www.implog.com/foundry/index.htm

American Metalcasting Consortium
http://amc.scra.org/

Modern Casting
http://www.moderncasting.com/

Enviroene Iron and Steel Foundry Content Guide
http://www.seattle.battelle.org/es-guide/iron/iron.htm

Appendix C

Acknowledgements

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